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An Economic Assessment of the Benefits of the Final Effluent Limitations Guidelines for Iron and Steel Manufacturers. Executive Summary, and Volumes I, II, and III

Public Interest Economics Center
Washington, DC

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Raucher, Robert L.

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An economic benefits assessment, and benefit-cost analysis of water quality improvements of the BPT and BAT Effluent Limitation Guidelines, promulgated May 1982, for Iron and Steel Manufacturers. This analysis represents a portion of the Regulatory Impact Analysis (RIA) required under Executive Order 12291.

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AN ECONOMIC ASSESSMENT OF THE BENEFITS OF THE FINAL EFFLUENT LIMITATIONS GUIDELINES FOR IRON AND STEEL MANUFACTURERS

Executive Summary

Volume I
Volume II
Volume III

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This document is presented in four parts:

- Executive Summary
- Volume I: Introduction
- Volume II: Allocating Shares of Estimates of the Aggregate Benefits of Water Pollution Control to the Iron and Steel Effluent Guidelines
- Volume III: The Benefits of Water Quality Improvements in Three Case Study Stream Segments

Robert L. Raucher, Ph.D.
Project manager and principal author

Research assistance provided by:
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AN ECONOMIC ASSESSMENT OF THE BENEFITS OF THE FINAL EFFLUENT LIMITATION GUIDELINES FOR IRON AND STEEL MANUFACTURERS

Executive Summary

May 1982
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Executive Summary

Summary of Findings:

This benefit-cost analysis of the effluent limitation guidelines for iron and steel manufacturers has pursued two lines of investigation. One approach has been to conduct in-depth analyses of the benefits attributable to the standards along three case study river segments. The second approach has been to attribute a portion of the estimated national benefits of water pollution control to abatement of iron and steel industry effluent, and then to BPT and BAT within the industry.

The principal findings of the case study streams analysis are that in moving from treatment now in place to BAT:

- On the Black River, in northern Ohio, the annual benefits are expected to range from $2.2 - 7.3 million, and the annualized compliance costs are projected at $2.7 - 3.2 million (in 1981 dollars).
- On the Mahoning River, in eastern Ohio and southwestern Pennsylvania, the annual benefits are expected to range from $2.3 - 12.1 million, and the annualized compliance costs are projected at $4.2 - 5.5 million (in 1981 dollars).
- On the lower Monongahela River, in southwestern Pennsylvania, the annual benefits are expected to range from $13.2 - 30.3 million, and the annual compliance costs are projected at $3.9 - 7.1 million (in 1981 dollars).
- There is a high probability that the present value of benefits would outweigh the present value of costs, when

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discounted at a rate of ten percent, for each of the three rivers studied.

The principal findings of the shares of aggregate benefits analysis are that:

- Because of the imprecision of national benefits estimates, coupled with conceptual difficulties with allocating shares to specific regulations, the aggregate shares approach generates benefit estimates of uncertain validity.
- The benefits of total water pollution abatement in the iron and steel industry, from 1972 conditions, are expected to range from $320 million to $4.95 billion per year (in 1981 dollars).
- The annual benefits of moving from in-place treatment to BPT are expected to range from $30 to $530 million. The annualized BPT compliance costs have been projected at $30 million (in 1981 dollars).
- The annual benefits of moving from BPT to BAT are expected to range from $6 to $198 million. The annualized BAT compliance costs have been projected at $17 million (in 1981 dollars).
- It appears likely that the present value of benefits would outweigh the present value of costs, when discounted at a rate of ten percent, for both BPT and BAT.

Introduction

Executive Order 12291 mandates that benefit-cost analyses be conducted for all major rules promulgated by Executive Agencies. In this report, the economic benefits of the final effluent limitation guidelines for iron and steel manufacturers are assessed and compared to the costs.

Analysis of the economic benefits of the proposed effluent limitation guidelines requires that all favorable outcomes be (1) identified, (2) quantified, and (3) valued in dollar terms. In order to properly execute this procedure, an enormous amount of scientific and socio-economic information is required. Due to acknowledged deficiencies in the relevant data and knowledge, it has been recognized by the Office of Management and Budget (OMB) that this economic benefit analysis represents an "experimental endeavor to identify both profitable lines of inquiry and areas of ignorance."[1] Accordingly, some of the empirical results provided below should be viewed as rough approximations of the benefits of the proposed guidelines. Ranges of estimates have been used wherever possible to avoid a false impression of precision. Nonetheless, these benefit ranges do provide useful information.

Scope of the Analysis

The benefit analysis has pursued two lines of investigation. Both lines of investigation have relied heavily on the existing economic and other professional literature, in accordance with

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[1] The Office of Management and Budget, "Comments on EPA's Proposed Review of Iron and Steel Effluent Guidelines," transmitted to EPA May 1981.

OMB's suggestion that "on-the-shelf" studies be used to facilitate benefit estimation.

The first line of investigation involves detailed analyses of the benefits derived from projected water quality improvements in three case study stream segments (portions of the Monongahela, Mahoning, and Black Rivers in Pennsylvania and Ohio). This case studies approach is presented in Volume III of the report.

The second approach to the analysis involves allocating shares of the aggregate benefits of water pollution control to the best practicable technology (BPT) and best available technology (BAT) effluent limitation guidelines for iron and steel manufacturers. This "aggregate shares" approach is addressed in Volume II of the report.

Results of Case Study Streams Analysis

EPA's Office of Water Regulations and Standards has performed relatively detailed analyses of the water quality improvements expected in three case study stream segments due to the BAT guidelines. We have used the information provided in these analyses to estimate the economic benefits of improving water quality in the three rivers from current conditions to those projected with BAT compliance.

As detailed in Volumes I and III of this report, the benefits of water pollution control are defined according to four categories: (1) recreation benefits, (2) nonuser benefits, (3) human health benefits, and (4) diversionary uses and commercial fisheries benefits. Our case study streams analysis has concentrated on the first two categories. This is because recreation and nonuser benefits are expected to constitute a significant portion of the total benefits for these rivers. In addition, time and data constraints prevented a thorough analysis of the remaining benefit categories.

For each of the three streams, recreation benefits have been estimated according to three distinct conceptual techniques. These are the application of participation models, recreation planning standards, and a willingness to pay survey. In the participation model approach, changes in activity days have been predicted according to the socioeconomic characteristics of the local population, the local supply of recreatable waters, and the quality of those waters. The recreation planning standards have been used to predict activity levels on the affected streams based on the average recreation use densities observed on other water bodies in the

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respective regions. The willingness to pay survey approach has been used to predict how much local residents would value recreation enabled by water quality improvements. The results of these separate analyses are presented in Table 1. For each river, the recreation benefits ranges are remarkably close given that they have been derived by different analytical techniques.

Nonuser benefits were derived according to two analytical techniques. One approach has combined survey results with information derived from the recreation analysis. The second approach has involved interpretation of survey responses according to surface water acreage. The results, as presented in Table 2, are also consistent across methodologies.

Nonuser and recreation benefits are totaled for each river in Table 3. The resulting ranges of annual benefits may be compared to the annualized cost figures that also are presented in Table 3. For both the Black and Mahoning Rivers, the ranges of compliance costs lie within the accompanying benefits ranges. This implies that one cannot state with absolute certainty whether or not the benefits would outweigh the cost of BAT along these rivers. However, the fact that the costs are nested in the lower end of the benefits range suggests that the net social benefits may indeed be positive. For the Monongahela River, the annual benefits unambiguously outweigh the costs.

Table 1
Recreation Benefits
(millions of 1981 dollars per year)

	Estimation Technique		
Black River	Participation Models	Recreation Planning Standards	Willing to Pay Survey[a]
1. Fishing	2.35-2.83	1.68-2.36	---
2. Boating	0.56-1.16	0.25-0.52	---
Total	2.91-3.99	1.93-2.88	2.44-4.83[b]
Mahoning River			
1. Fishing	0.25-0.39	2.15-2.73	---
2. Boating	1.30-2.70	1.29-2.68	---
Total	1.55-3.09	3.44-5.41	5.81-8.08[b]
Monongahela River			
1. Fishing	5.60-6.72	10.05-12.75	---
2. Boating	4.53-9.42	1.94-4.04	---
Total	10.13-16.14	11.99-16.79	12.30-20.24[b]

[a] The willingness to pay survey includes benefits of attaining swimmable water quality, as well as fishable and boatable waters.

[b] The willingness to pay figures presented in this table have been adjusted to delete nonuser benefits. Half of the average fishing benefit estimates have been used to make the nonuser benefit adjustment.

[c] On the Monongahela, up to half of the boating activity might be attributed to increased fishing. Correcting for this potential double counting would yield a lower bound recreation benefits estimate of $7.87 million along the Monongahela.

Table 2
Nonuser Benefits
(millions of 1981 dollars per year)

	Estimation Technique			
	Recreation Proportional		Acreage Proportional	
	lower bound	upper bound	lower bound	upper bound
Black	$0.91	$1.49	$0.24	$4.08
Mahoning	0.91	2.15	0.70	12.00
Monongahela	17.99	21.57	3.08	52.69

Table 3
The Annual Benefits and Costs of Moving from Current Treatment to BAT
(millions of 1981 dollars per year)

River	Total Benefits			Total Costs[a]	
	Lower Bound[b]	Best Judgement Upper Bound[c]	Actual Upper Bound	Lower Bound	Upper Bound
Black	2.17	7.25	8.91	2.69	3.16
Mahoning	2.25	12.12	20.08	4.20	5.50
Monongahela	13.21	30.36	72.93	3.87	7.07
Total	17.63	49.73	101.92	10.76	15.73

[a] Annualized costs reflect yearly operation and maintenance costs plus annual capital costs (based on capital recovery factor of .0899), and include costs of treatment for facilities under construction. Source: Office of Water Regulations and Standards, U.S. EPA, and Region III and Region V Enforcement.

[b] The lower bound estimates were derived by summing the lowest recreation benefit estimate (from Table 1) and the lowest nonuser benefit estimate (from Table 2) for each river. The actual upper bound estimates were derived in similar fashion, summing the greatest recreation and nonuser values.

[c] Best judgement upper bound estimates were derived by constraining nonuser benefits to be no greater than half of the upper bound estimate for recreation benefits (from Table 1), and then adding this figure to the upper bound recreation estimate.

The annualized figures from Table 3 need to be analyzed according to the present value of the lifetime streams of benefits and costs. The benefits and costs of the proposed effluent guidelines, as discounted, are presented in Table 4. Using midpoints of the ranges of costs and benefits to calculate present values, the discounted net social benefits are greater than zero for all three rivers at both 6% and 10% rates of discount.

The use of cost and benefit midpoints to calculate net benefits, as in Table 4, may be slightly misleading. Because the ranges of annual benefits are broader than the annual cost ranges, and because the annualized costs are within the benefits range for two of the three rivers (see Table 3), using the lower bound benefit estimates in the net benefit calculations would produce negative net social benefits for those rivers. Therefore it is useful to determine the level of annual benefits required to yield present value benefits in excess of costs. Such "required" benefits have been calculated and are shown in relation to the estimated range of benefits in Table 5. The table also presents the probability, assuming a uniform distribution, that the required benefit level would be attained. Accordingly, it is shown that there is high probability that the net social benefits are positive for the Black and Mahoning Rivers. The present value of net social benefits is virtually certain to be positive for the Monongahela River. This suggests that the benefits of moving from current treatment to BAT will outweigh the costs for all three rivers studied.

Table 4
Present Value of Net Social Benefits Under Alternate Discount Rates
(millions of 1981 dollars)

	Costs[a]		Discounted Present Value		
Discount Rate = 10%:	Capital Outlay	Annual O&M Costs	Benefits[b]	Costs[c]	Net Benefits[d]
Black River	$16.24	$ 1.73	$ 47.00	$38.35	$ 8.65
Mahoning River	31.61	2.01	71.85	61.07	10.78
Monongahela River	26.18	3.25	217.85	66.43	151.42
Discount Rate = 6%:					
Black River	$16.24	$ 1.73	$ 78.33	$54.67	$ 23.66
Mahoning River	31.61	2.01	119.75	83.79	35.96
Monongahela River	26.18	3.25	363.17	95.82	267.35

[a] Costs are midpoints of ranges, presented in Table 3.

[b] Benefits are based on midpoints of the "best judgement" range from Table 3.

[c] The present value of costs is equal to the initial capital outlay, plus the present value of an infinite stream of future annual operation and maintenance costs, plus the present value of capital replacement costs after fifteen and thirty years.

[d] Present value of net social benefits equals the present value of benefits less the present value of costs.

Table 5
Probability That the Present Value of Net Social Benefits is Positive

	"Best Judgement" Annual Benefits Range (millions of 1981 dollars)[a]	Annual Benefits Required for PV(B)>PV(C)[b]	Probability that PV(B)>PV(C)[c]
Discount Rate = 10%:			
Black River	$2.17-$7.25	$3.84	62.1%
Mahoning River	2.25-12.12	6.11	55.9
Monongahela River	13.21-30.36	6.64	95.0+
Discount Rate = 6%:			
Black River	$2.17-$7.25	$3.28	73.1%
Mahoning River	2.25-12.12	5.03	66.8
Monongahela River	13.21-30.36	5.75	95.0+

[a] From Table 3.

[b] PV(B) denotes the present value of benefits and PV(C) denotes the present value of costs. The required benefit figures were calculated from the present value of costs from Table 4.

[c] Based on the assumption that the probability distribution within the "best judgement range" of benefits is uniform, and that the range itself represents a 90% confidence interval.

Results of the Aggregate Shares Analysis

One approach to estimating the benefits of the proposed effluent guidelines by way of "on-the-shelf studies" is to allocate a share of existing estimates of the aggregate benefits of controlling water pollution to the BPT and BAT abatement efforts by the steel industry. This aggregate shares approach to estimating the benefits of specific regulatory activities consists of (1) using existing estimates of the national benefits of controlling water pollution, and (2) allocating a percentage of these aggregate benefit estimates to specific abatement efforts (here, BPT and BAT) by a single industry (iron and steel). The validity of this approach is therefore contingent on the accuracy and relevance of (1) the aggregate benefit estimates, and (2) the methodology employed to attribute shares of the benefits to the individual regulation.

There are several published studies in which the national benefits of water pollution control have been derived. The most notable of these studies is a 1979 report, authored by A. Myrick Freeman, for the Council on Environment Quality[2]. Freeman reviewed the studies that have generated estimates of the total benefits to be derived from pollution control, adjusted the estimates to make them consistent, and then used his professional judgement to synthesize a range of aggregate benefit estimates of his own. We have reviewed Freeman's estimates, as well as those from the underlying studies, in order to determine whether they were (1) valid in the sense of being derived from sound data and appropriate analytical techniques, and (2) relevant for evaluating reductions in iron and steel discharges in terms of the sources and types of pollutants analyzed. We also have investigated aggregate benefit estimates derived from studies conducted since the completion of Freeman's report. Consequently, we have synthesized our own range of aggregate benefit estimates, based to a large extent on Freeman's work, but made more relevant by the inclusion of results generated by more recent research. These benefit figures, along with Freeman's original estimates, are provided in Table 6. It is important to recognize that these estimates may be imprecise. This is because in some instances the effects of relevant pollutants (notably, toxics) have been omitted. The estimates also do not account in most cases for the impacts of nonpoint sources of pollution. More importantly, most of the underlying studies are based on weak water quality models and severely limited data. Therefore, at best, aggregate benefit estimates may be used to suggest a very broad range of national benefit values.

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[2] Freeman, A. M., III, The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, Council on Environmental Quality, Washington, D.C., 1979.

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Table 6
The National Benefits of Water Pollution Control
(billions of 1981 dollars per year)

Benefit Category	Freeman's Range[a]	Freeman's Range as Adjusted by EPA[b]
Recreation	$5.7 - 19.5	$2.5 - 25.0
Nonuser	1.4 - 6.9	0.7 - 12.0
Human Health[c]	0.0 - 2.8	2.0 - 47.8
Diversionary Uses	1.5 - 3.5	1.7 - 3.7
Commercial Fisheries	0.6 - 1.7	0.6 - 1.7
TOTAL[d]	$9.2 - 34.3	$7.5 - 90.2

[a] Freeman, M., The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, CEQ, December 1979.

[b] All adjustments are described in Volume II.

[c] The large difference in the ranges of human health benefits is due to the inclusion of carcinogens in the EPA analysis (see Volume II).

[d] If health benefits are omitted from the totals, the ranges are very comparable: Freeman would have $9.2 - $31.5 billion, and the EPA range be would $5.5 - $42.4 billion.

The second portion of the aggregate shares approach analysis pertains to the issue of whether a percentage of the national benefit estimates may be attributed in a valid fashion to the proposed guidelines. Shares of pollutant loadings generally are used to define benefit shares. The hypothesized relationship between loadings and benefits presents two basic problems: (1) Can loadings shares be defined accurately? and (2) Can the loading shares then be translated into benefit shares?

The iron and steel industry's share of all point source loadings for conventional pollutants is shown in Table 7. The industry is responsible for 7.0% of all discharges for the pollutant categories shown. Averaging this percentage with a 6.0% estimate derived from loadings information for selected toxics results in 6.5% industry share estimate. Applying the latter percentage to the portion of the aggregate benefit estimates attributable to point sources, the total annual benefits of complete abatement of iron and steel effluent, from a 1972 loadings baseline, have been calculated and are presented in Table 8. Between $320 million and $4.95 billion are estimated to be the annual benefits of moving the industry from its 1972 pollution levels to zero discharge.

Table 7

The Iron and Steel Industry's Share of Conventional Point Source Loadings[a]

(millions of pounds discharged annually)

Pollutant	Direct Industrial Discharges	Municipal Discharges	Total Point Source Discharges	Iron & Steel Discharges[b]	Iron & Steel's Share of Total
Total Suspended Solids (TSS)	1,733	1,250	2,983	278	9.7%
Chemical Oxygen Demand (COD)	3,455	2,183	5,638	508	9.0%
Biological Oxygen Demand (BOD)	1,804	1,250	3,054	76	0.8%
TOTALS	6,992	4,683	11,675	811	7.0%

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[a] Loadings reflect 1968 discharge levels, derived from Research Needs and Priorities: Water Pollution Control Benefits and Costs, Vol. II, Table A-5, EPA 600/5-73-0086, October 1973.

[b] Iron and steel loadings based on the industry's shares of primary metals loadings, by pollutant category, from Council on Environmental Quality, Environmental Quality, First Annual Report, August 1970.

Table 8

Annual Benefits Attributable to Iron and Steel Zero Discharge[a]

(billions of 1981 dollars per year)

Benefit Category	Lower Bound	Midpoint	Upper Bound
1. Recreation	$0.14	$0.84	$1.54
2. Nonuser	0.04	0.35	0.66
3. Diversionary Uses and Commercial Fisheries	0.08	0.19	0.29
4. Human Health[b]	0.07	1.26	2.46
TOTAL[c]	$ 0.32	$ 2.64	$ 4.95

[a] Relative to 1972 levels of discharge.

[b] For human health, the aggregate benefits due to bacterial disease control have been excluded as they are not relevant to industry discharges.

[c] Totals may not add due to rounding.

The benefit estimates presented above in Table 8 pertain to the values of moving from industry pollution levels in 1972 to total elimination of discharge. In order to calculate the portion of those benefits attributable to BPT and BAT, the incremental percentages of discharge removed by those technologies, from the 1972 baseline, have been calculated and are shown in Table 9. Moving from current in-place treatment to full compliance with BPT would reduce toxic loadings by over 2,300 tons annually. This would comprise 10.7% of the toxic pollutants discharged in 1972. BAT would result in an additional 4.0% removal of toxic organics and toxic metals. The BPT and BAT removal shares are 9.3% and 1.9% respectively when other pollutants are included in the calculations.

The BPT and BAT loadings reduction shares from Table 9 have been applied towards the total benefits of industry abatement, from Table 8, and the resulting range of benefit estimates are presented in Table 10. The annual BPT and BAT compliance costs, also shown in Table 10, are in the lower end of the benefits range for both technologies. This implies that the benefits would probably exceed costs for both BPT and BAT.

The discounted stream of future benefits and costs are then provided in Table 11. The results suggest that for both BPT and BAT, the present value of benefits would be expected to outweigh the present value of costs.

Table 9

Pollutant Removals by BPT and BAT Relative to 1972 Discharge Levels
(tons per year and percentage removal)

Pollutant Category	1972 discharges for iron and steel	Removal as of 1981		Incremental BPT Removal		Incremental BAT Removal	
		tons	%	tons	%[a]	tons	%[a]
Toxic Organics	12,500	10,090	80.1%	1,690	13.5%	587	4.7%
Toxic Metals	9,200	8,020	87.2%	624	6.8%	277	3.0%
SUBTOTAL	21,700	18,110	83.5%	2,314	10.7%	864	4.0%
Other Pollutants[b]	660,000	555,000	84.1%	60,988	9.2%	12,290	1.9%
TOTAL	681,700	573,110	84.1%	63,302	9.3%	13,154	1.9%

[a] Incremental percentage removals are calculated from the 1972 baseline.

[b] The other pollutants category consists of suspended solids, oil and grease, ammonia, sulfide, phiocynate, and fluoride.

Table 10

Annual Benefits and Costs of BPT and BAT
(millions of 1981 dollars)

Treatment	Annual Benefits[a]		Annual Costs[b]
	Lower Bound	Upper Bound	
Current to BPT	$ 29.8	$ 529.7	$ 30.4
BPT to BAT	6.1	198.0	17.1

[a] Derived from results shown in Table 8 and Table 9.

[b] Derived from 1980 costs as presented in An Economic Analysis of Final Effluent Limitation Guidelines, New Source Performance Standards, and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category, U.S. EPA.

Table 11

Present Value of the Benefits and Costs of BPT and BAT
(millions of 1981 dollars)

	Benefits[a]	Costs[b]	Probability that Benefits Exceed Costs[c]
Discount Rate = 10%			
BPT	\$ 298 - \$ 5,297	\$ 334	94.2%
BAT	61 - 1,980	182	88.7%
Discount Rate = 6%			
BPT	497 - 8,828	514	94.8%
BAT	102 - 3,300	288	89.2%

[a] Derived by discounting results presented in Table 10.

[b] Present value of costs equals the initial capital outlay, the discounted value of capital replacement costs in fifteen and thirty years, and the discounted stream of infinite operation and maintenance costs. The capital and variable costs are from An Economic Analysis of Final Effluent Limitation Guidelines, New Source Performance Standards, and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category, U.S. EPA.

[c] Based on the assumption that the benefits range represents a 90% confidence interval with a uniform distribution.

While it has been relatively straightforward to calculate benefit figures based on the industry's percentage share of discharge, we do not regard the resulting estimates with much confidence. This is due to the fact that pollutant loadings are not necessarily sound proxies of economic benefits. Different pollutants are associated with varying types and degrees of environmental damage. Further, reductions in environmental damages will yield varying levels of economic benefits depending on the specific water body and the characterisitcs of the surrounding population. In short, benefits are not strictly proportional to loading reductions. Without intricate weighting schemes that would account for relevant factors such as toxicity, flow, and population, we believe that the aggregate shares approach to benefits estimation might generate errors of indeterminant direction and magnitude.

AN ECONOMIC ASSESSMENT OF THE BENEFITS OF THE FINAL EFFLUENT LIMITATION GUIDELINES FOR IRON AND STEEL MANAUFACTURERS

Volume I: Introduction

May 1982
Benefits Staff
Office of Policy Analysis
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Volume II: Allocating Shares of Estimates of the Aggregate Benefits of Water Pollution Control to the Iron and Steel Effluent Guidelines

Volume III: The Benefits of Water Quality Improvements in Three Case Study Stream Segments

1. Introduction and Outline

This report contains an economic analysis of the benefits of the final effluent limitation guidelines for iron and steel manufacturers. These effluent guidelines establish standards for levels of water pollution discharges, by industrial category, that are associated with best practicable technology (BPT) and best available technology (BAT) in accordance with the Federal Water Pollution Control Act of 1972, as amended in 1977. Compliance with the BPT effluent guidelines is mandated by July 1, 1983. BAT compliance is required by July 1, 1984.

The structure of the report is as follows. This portion of the report, Volume I, contains an introduction to the remainder of the economic benefit analysis. The introduction includes a conceptual description of the types of benefits associated with the control of water pollution. This is followed by discussion of the causal relationships that link regulatory actions to the beneficial outcomes that society values. The gap between information required and available to estimate these benefits is also described, as is the general methodology employed in the analysis. The intent of Volume I is to provide background information and to clarify in general terms the limitations of this and other efforts to project the economic benefits of regulations that control water pollution.

Volume II of the report contains the analysis of one approach to benefit estimation - calculating shares of estimated national or aggregate benefits of water pollution control to attribute to the specific BPT and BAT regulations for the iron and steel industry

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industry. The first part of Volume II contains to an evaluation of the research that has generated the existing estimates of the aggregate benefits. The second part addresses issues concerning the allocation of portions of the aggregate benefit estimates to the proposed guidelines. Finally, a range of the benefits attributable to BPT and BAT is presented, as are caveats and the limitations of the analysis.

Volume III contains detailed analyses of the economic benefits expected due to projected water quality improvements in the Monongahela River in Pennsylvania, and the Black and Mahoning Rivers in Ohio. These case study stream analyses are followed by a discussion of what inferences can and cannot be drawn from the three study segments in terms of evaluating the regulation as a whole.

2. Benefit Categories

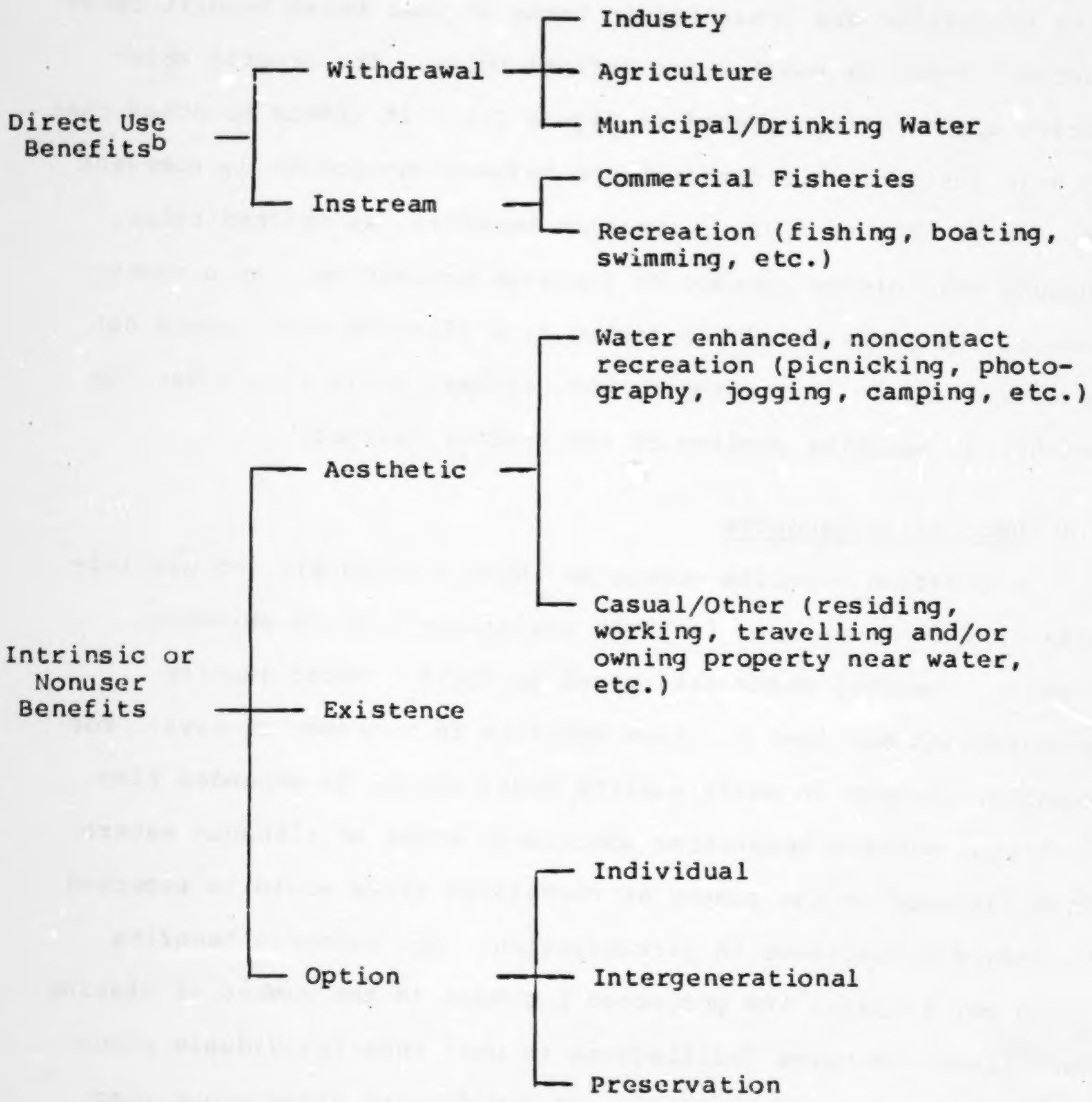
Both the aggregate shares and case study approaches to benefits estimation are presented in terms of four broad benefit categories. These categories are defined below. The benefit categories also are represented in Figure I-1. It should be noted that in some instances the distinctions between categories is somewhat arbitrary. For example, recreation benefits, as defined below, include only direct contact or instream activities. As a consequence, the pleasure of picnicking by a cleansed river would not be considered in that category but, rather, would fall under the aesthetics benefits portion of the nonuser category.

2.1 Recreation Benefits

Recreation benefits accrue to those individuals who participate in direct contact, instream activities such as swimming, fishing, boating, water skiing and so forth. Water quality improvements may lead to these benefits in a number of ways. For example, changes in water quality might result in expanded fish habitats, thereby generating additional acres of fishable waters. This increase in the supply of recreation sites would be expected to induce an increase in participation. The economic benefits would be, in part, the projected increase in the number of fishing days times the value (willingness to pay) that individuals place on that activity. The addition of new fishing areas might also relieve congestion at existing sites, thereby increasing the utility of those who continue to fish those waters.

Figure I-1

The Benefits of Water Quality Improvements[a]


Direct Use Benefits[b]
Withdrawal
Industry
Agriculture
Municipal/Drinking Water
Instream
Commercial Fisheries
Recreation (fishing, boating, swimming, etc.)
Intrinsic or Nonuser Benefits
Aesthetic
Water enhanced, noncontact recreation (picnicking, photography, jogging, camping, etc.)
Casual/Other (residing, working, travelling and/or owning property near water, etc.)
Existence
Option
Individual
Intergenerational
Preservation

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[a] The format of this figure is based on a similar diagram in Mitchell, R. and Carson, R. (forthcoming).

[b] Direct use benefits encompass recreation, health, diversionary uses and commercial fisheries benefits.

Water quality improvements also yield benefits when they occur in streams where fishing already occurs. This results when desired species (such as trout, salmon or bass) rehabitate a stream so that the quantity and quality of a fishers' catch improves. These individuals also benefit because the aesthetic pleasure of recreating on the river increases. As a consequence, current users of the stream value each of their fishing days more highly. Furthermore, the improved aesthetics and fish habitats would be expected to induce increased participation, resulting in additional benefits.

For swimming, boating, and other forms of recreation, water quality improvements generate benefits in a similar fashion. The overall level of the recreation activity is likely to increase, and the value of the recreation experience will also increase for previous levels of use.

2.2 Nonuser Benefits

Nonuser or intrinsic benefits encompass non-contact, water-enhanced recreation and other aesthetic benefits, plus option and existence values. None of these benefits are associated with the current direct use of water (although option values relate to potential direct use).

Aesthetic benefits reflect the value of improved water quality to people residing, working, and/or travelling near affected water bodies. These benefits may be captured, in part, in increased property values. Aesthetic benefits also accrue to individuals participating in near-stream, water-enhanced recreation activities, such as picnicking, wildlife watching, photography, camping, walking, and so forth.

Option value benefits pertain to the value of preserving the possibility of future use by those not currently using, or planning to use, affected water resources. Option benefits reflect the value of reducing uncertainties and of avoiding irreversibilities. Option values are relevant on a personal basis, that is, an individual wishing to preserve the option to use the water themselves at some future date. Option values also reflect intergenerational concerns. This is sometimes referred to as a bequest motive - preserving the option of future generations to utilize untainted waterways. The preservation of ecosystems and species reflects another component of option value, reflecting the concern that irreversible damages might adversely affect social welfare in the near or distant future.

Existence benefits are the third major component of the non-user or intrinsic benefits category. Existence benefits pertain to the value that individuals place on knowing that waterways that they have no intention of ever using are less polluted, and that aquatic ecosystems are being protected. These values are distinct from aesthetic benefits and concerns over retaining the option of future use.

2.3 Human Health Benefits

Health benefits arise from expected reductions in human exposure to harmful substances through ingestion of contaminated drinking water, processed foodstuffs, and fish. Dermal exposures by way of swimming and boating are also relevant. The value of these health benefits is derived by calculating the reduction in the risks of illness and premature fatality over the exposed populations. The expected number of illnesses and fatalities avoided are then multiplied by the dollar value of eliminating each such effect. The measurement and valuation of health benefits is discussed in greater detail in Section 3.7 below.

2.4 Diversionary Uses and Commercial Fisheries Benefits

This benefit category consists of the cost savings and productivity gains that improved water quality might bring to existing and potential diverters of stream waters and commercial fisheries. Diversionary uses benefits would include reductions in treatment costs for municipal water supplies, plus benefits that might accrue to households (due to reduced hardness, for example) and cost savings to industrial users of process or cooling water. Similar benefits might accrue to agricultural users of water.

Commercial fisheries benefits include increased productivity in terms of diversity and size of catch per unit of effort. The cost savings and productivity gains for diversionary users of water and commercial fisheries may also yield distributional benefits, such as reduced prices for consumers.

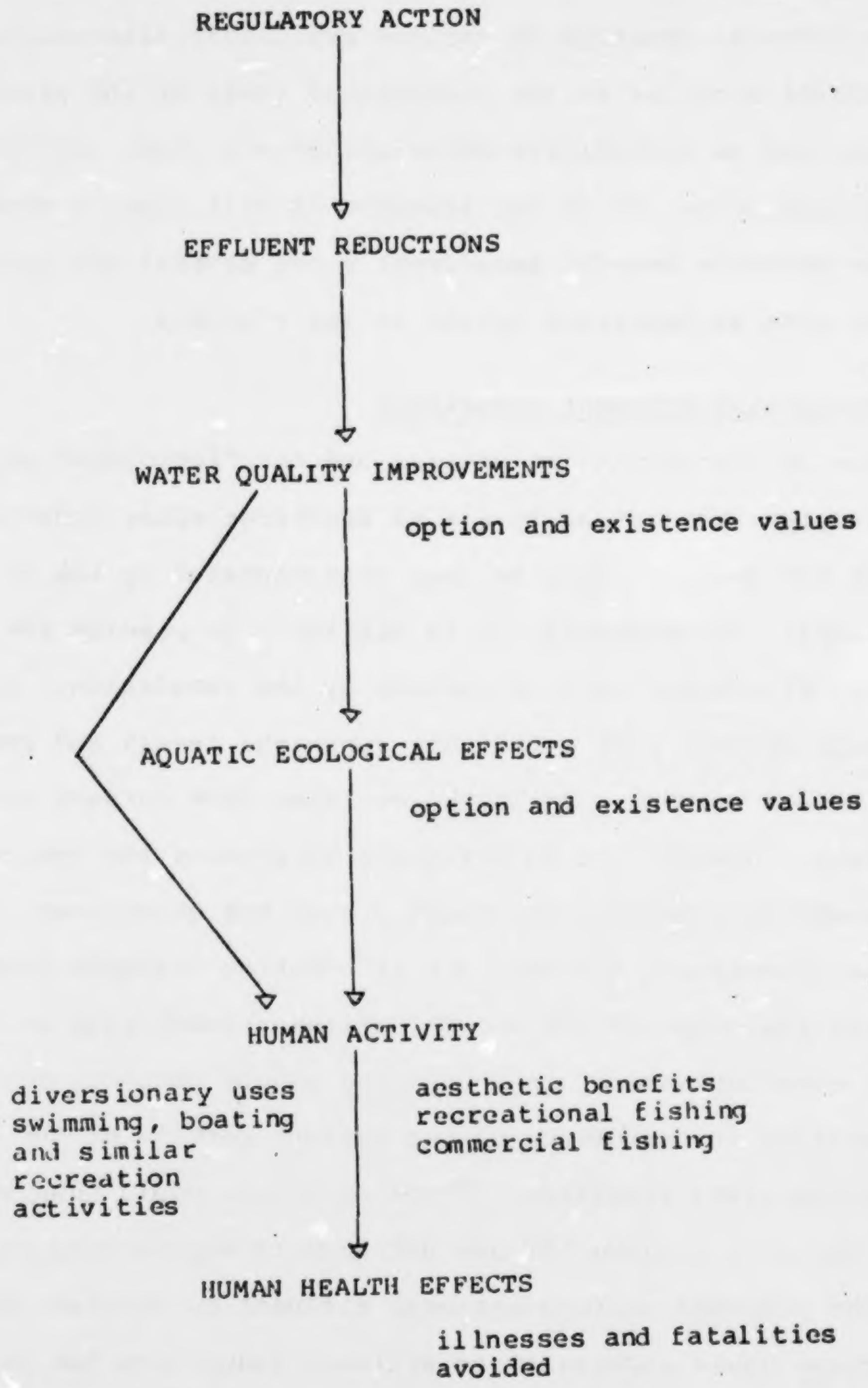
3. Information Required to Conduct Economic Benefit Analyses

The primary difficulty confronted in performing an economic benefits assessment of effluent limitation guidelines is that an extremely large set of data is required for such an analysis, and large portions of that needed information currently are nonexistent. The purpose of this section of the report is to describe the causal relationships that link the regulation to economic benefits, and the subsequent gap between the information required and that which is available for conducting benefit assessments.

3.1 Causal Relationships and Benefits Assessment

In order to conduct an economic benefit analysis of a regulatory action, all of its favorable outcomes first must be identified, then quantified, and finally, converted to a common measure - usually dollars. For the iron and steel effluent limitation guidelines, a benefit assessment must (1) convert the proposed regulations into expected reductions in effluent, (2) translate the projected effluent reductions into specific improvements in water quality, (3) relate the projected water quality improvements to specific types and levels of aquatic, human health, and other physical or biological effects, (4) predict changes in the level of valued activities, such as recreational fishing, that will arise as a result of the ecological effects, and (5) place dollar values on all of the beneficial outcomes. This chain of events or causal relationships from regulatory action to the outcomes that society values is depicted in Figure I-2.

Figure I-2
Causal Relations and Benefits Assessment


REGULATORY ACTION
EFFLUENT REDUCTIONS
WATER QUALITY IMPROVEMENTS
option and existence values
AQUATIC ECOLOGICAL EFFECTS
option and existence values
HUMAN ACTIVITY
diversionary uses swimming, boating and similar recreation activities
aesthetic benefits recreational fishing commercial fishing
HUMAN HEALTH EFFECTS
illnesses and fatalities avoided

Ideally, the types and levels of all valued outcomes would be identified and valued in dollar terms, insofar as possible, so that the incremental benefits of various regulatory alternatives could be compared directly to the incremental costs of the programs. However, due to information deficiencies and other difficulties, as detailed below, it is not feasible at this time to conduct a precise economic benefit assessment since several key assumptions must be made at important points in the analysis.

3.2 Predicting Effluent Reductions

Due to the permitting process and the "lumpiness" of treatment technologies, the actual levels of discharge after compliance with BPT and BAT probably will be less than mandated by the effluent guidelines. Consequently, it is difficult to predict the amounts by which discharges will be reduced by the regulation. Ideally, one would project post compliance discharge levels and compare them to pollutant loading conditions resulting from current treatment practices. However, it is difficult to predict the extent to which post compliance performance might exceed the guidelines.

An alternative scenario for calculating effluent reductions compares the proposed BPT and BAT effluent guidelines to current permit restrictions. This accounting scheme neglects any abatement that exceeds in stringency either current permits or the proposed technology-based standards. These omissions would tend to balance out. However, because BPT and BAT permits may be more stringent than the proposed uniform national effluent guidelines, this accounting would underestimate effluent reductions due to the regulation. Nonetheless, this is the framework that generally has been employed to approximate reductions in discharge expected with compliance with permits issued in accordance with the BPT and BAT effluent guidelines.

3.3 Predicting Changes in Water Quality

The changes in water quality resulting from a stated level of effluent reduction depend extensively on the physical properties of the receiving body of water. Water temperature, hardness, pH level, depth, and flow all affect the ability of a stream or lake to dilute and assimilate the various relevant pollutants. Water quality is also dependent on the types and levels of effluent arising from dischargers other than iron and steel plants, as well as from non-point sources. Therefore, a completely accurate benefit analysis of this regulation would have to be site-specific, accounting for the unique physical properties and loadings from all local sources in each affected stream segment.

The relationship between effluent reductions and water quality improvements may represent one of the weaker links in benefit analyses of water pollution controls. First, the effluent reductions are not always well defined for reasons described above. Second, predicting the resulting change in the physical properties of the receiving water bodies involves simulation modelling that requires extensive information and a large level of effort for each affected stream or lake. For example, as part of the regulatory impact analyses for these effuent guidelines, the EPA's Office of Water Regulations and Standards (OWRS) has performed relatively detailed water quality analyses for selected stretches of three stream segments. Despite the large level of effort devoted to this work, the results are somewhat limited in scope. The level of effort required to generate relatively comprehensive water quality analyses for three short river stretches illustrates that the task of soundly analyzing all relevant waterways is beyond present capabilities.

Without improved water quality analyses, economic benefit assessment remains a somewhat academic exercise. The benefit analyses of the case study streams presented in Volume III to some extent have been limited by the lack of underlying scientific information. The aggregate shares approach, detailed in Volume II of this report, has also been limited by the same factors. The existing aggregate benefits estimates have been derived from water quality models that can be characterized as crude at best, ignoring nonpoint source pollution and using simple water quality measures such as dissolved oxygen as proxies for (or worse, in lieu of) a broader range of relevant pollutants. Further, current levels of total and industry-specific discharges are poorly understood. Consequently, one of the findings of this report is that detailed water quality analyses may represent a profitable line of future inquiry in terms of providing useful information to decision makers.

3.4 Predicting Aquatic Ecological Effects

If water quality improvements could be specified for each affected water body, or even for a subsample of sites, the next step in the analysis would be to predict the induced ecological outcomes. Specifically, the predicted changes in water quality parameters, such as dissolved oxygen and concentrations of cyanide and other substances, have to be translated into quantified physical effects, such as changes in fish habitats. For example, it is necessary to know whether a stream that now supports only carp could sustain a healthy bass fishery after compliance with the regulation. Such predictions of expanded habitats for certain desirable, pollution-sensitive species depend on the species and water quality characteristics relevant at each site. Because the policy induced changes in water quality may not always be well understood, even where specific streams are studied in some depth, several assumptions regarding the aquatic effects of the proposed effluent reduction must be made in this and other benefit analyses.

3.5 Predicted Changes in the Level and Value of Recreation

Projected improvements in water quality, and the subsequent expansion of fish habitats, swimmable waters and so forth, lead to enhanced opportunities to recreate. In a benefit analysis, one must establish a relationship between the enhancement of specific recreational opportunities and changes in the level and value of the affected activities. In essence, the problem is one of predicting changes in human behavior in response to changes in the environment. For example, the level and value of recreational fishing generally is characterized by demand functions in which fishing days are determined by recreational opportunities, income and other socioeconomic variables, perceived water quality, and expectations concerning catch. There are various economic techniques that may be used to explain existing participation levels and to calculate the associated willingness to pay. The accuracy of these models in terms of predicting changes in levels and values in response to improved conditions is not as clearly established, though their ability to account for current use suggests that such predictions would be reasonably accurate.

3.6 Predicting Nonuser Benefits

Nonuser benefits are especially difficult to measure and project. Portions of the aesthetic component of this benefit category may be reflected in property values. However, it is difficult to attribute gains in such values with specific water quality improvements. This is due largely to data limitations. Even where such a causal relationship can be isolated and estimated, one must avoid double counting by separating recreation and other benefits from the portion of the value to be attributed to improved aesthetics. Option and existence values generally are measured by hypothetical valuation survey instruments. The results of such willingness to pay questionnaires may be susceptible to a wide range of biases and errors unless the surveys are designed, administered, and evaluated carefully. Such surveys provide nearly all the available information on nonuser benefits, and they have been applied to this analysis.

3.7 Predicting Human Health Effects

Changes in water quality arising from effluent reductions can have direct and indirect effects on human health. However, predicting health effects is difficult because (1) both water quality improvements and water uses are site-specific, (2) there are uncertainties concerning how interceding human behavior affects exposure (i.e., by treating drinking water or eating fish), and (3) there are uncertainties regarding the relationship between exposures (doses) and health effects (responses).

Where receiving water bodies are used for public drinking water supplies, reduced contamination may have a direct impact on health. The types and levels of the illnesses avoided depend on the specific pollutants, the relevant dose-response relationships, and on the treatment capabilities of the water utilities. Ingestion of fish from polluted waters, and dermal exposure by way of swimming in them, are other links between water quality and human health.

Efforts to estimate the health impacts of water pollution generally have relied on macro epidemiological research limited to mortality. These attempts to link very general water quality characteristics (such as whether a population's drinking water is drawn from surface sources) to the incidence of broadly categorized fatal diseases (such as cancer) are limited analyses and are often the subject of debate. In part, this is due to the fact that data are unavailable that would allow for the control of the many relevant confounding factors (such as occupation, smoking, length of exposure, etc.).

Health effects also may be predicted on the basis of laboratory experiments with animals. These experiments control for many of the factors that complicate epidemiological work, but they fail to account for possible synergistic effects. There are also difficulties in extrapolating the results of high dose animal exposure experiments to predict the results of low dose exposures in humans. Important strides have been made in the area of quantifying dose-response risk assessments, especially for carcinogens. However, several problems remain, not the least of which is predicting levels of exposure.

Where exposures and subsequent health risks can be quantified in a meaningful way, the predicted number of illnesses and premature fatalities avoided need to be valued in dollar terms. There is a fairly extensive economics literature pertaining to the value of reducing risks to life. This provides estimates of the value of saving a "statistical life", that is, the willingness to pay to save the life of an unidentified individual who otherwise would have been drawn at random from the exposed population and afflicted with a fatal disease or accident. The range of values often cited for saving a statistical life is from $300,000 to $2.5 million. However, it should be noted that this range of values pertains to voluntary, compensated risks such as associated with certain occupational hazards. They may therefore understate the life values associated with involuntary and uncompensated exposure to risk. Further, some of the estimates have been derived from the behavior of individuals who may not be as averse to risk as the population as a whole. In addition, adjustment might be appropriate in order to account for the number and quality of life years lost, the type of death incurred, and the length and extent of the suffering preceeding death.

A more difficult health effects valuation problem pertains to non-fatal illnesses. Little is known about the willingness of individuals to pay to avoid morbidity. Medical expenses incurred and lost earnings only establish what it costs to be ill. Such costs may serve only as a crude lower bound estimate for the value that people place on being healthy.

3.8 Conclusions on Causal Relationships

An analysis of the economic benefits of effluent limitation guidelines requires that a long and complex chain of causal relationships be well understood. This chain runs from the setting of the guidelines to reductions in effluent to water quality improvements to aquatic ecology effects to changes in interceding human behavior to human health effects. Data deficiencies, scientific uncertainties, socioeconomic considerations, and a host of other complicating factors severely limit our understanding of these key relationships. Accordingly, several assumptions must be made at many integral points of the analysis. Until data and analytical abilities improve, such assumptions are unavoidable. Nonetheless, these assumptions may severely limit the accuracy of economic benefit analyses of effluent guidelines. The purpose of this portion of the report has been to draw attention to this gap between the information that is required and that which is currently available to conduct these benefit studies and, thereby, to highlight the limitations of such benefit analyses and point out useful areas for future research. The analyses presented in the following two volumes of this report should be viewed as an attempt to develop a consistent, integrated analytic benefits framework. We have attempted to conceptualize the economic benefits of the final effluent guidelines for iron and steel manufacturers, and to estimate a range of values for those benefits. In this manner, we hope to contribute to the the body of useful information, while at at the same time avoiding a false impression of precision.

4. The Scope and General Methodology of the Benefit Analysis

In recognition of the complexity of conducting an economic benefit asssessment of the effluent guidelines, as detailed in the preceeding section, the Office of Management and Budget (OMB) has suggested that the Agency use "on-the-shelf studies to quantify and/or monetize the expected benefits to be realized with the projected changes in water quality...[1]." Accordingly, EPA's benefit analysis has consisted of a thorough search, review, and application of both existing literature and research in progress. OMB has also stated that "it should be recognized, though, that this study will be a largely experimental endeavor to identify both profitable lines of inquiry and areas of ignorance.[2]" This is the appropriate perspective with which to view this benefit analysis. The methodology employed in this endeavor is described below.

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[1] Office of Management and Budget, "Comments on EPA's Proposed Review of Iron and Steel Effluent Guidelines," transmitted to EPA May 1981, p. 2.

[2] *Ibid*, p. 3.

4.1 General Methodology: Aggregate Shares Approach

One approach to estimating the benefits of the proposed effluent guidelines by way of "on-the-shelf studies" is to allocate a share of existing estimates of the aggregate benefits of controlling water pollution to the BPT and BAT abatement efforts by the steel industry. If the existing aggregate benefit estimates are reasonably accurate, and if a portion of the benefit figures can be attributed in a valid fashion to a given set of effluent guidelines, affecting a single industrial discharger, then one can obtain an estimate of the benefits of that specific regulation.

There are several published studies in which the national benefits of water pollution control have been derived. The most notable of these studies is a 1979 report, authored by A. Myrick Freeman, for the Council on Environmental Quality[3]. Freeman reviewed the studies that have generated estimates of the total benefits to be derived from pollution control, adjusted the estimates to make them consistent, and then used his professional judgement to synthesize a range of aggregate benefit estimates of his own. We have reviewed Freeman's estimates, as well as those from the underlying studies, in order to determine whether they were (1) valid in the sense of being derived from sound data and appropriate analytical techniques, and (2) relevant for evaluating reductions in iron and steel discharges in terms of the sources and types of pollutants analyzed. We have also investigated aggregate

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[3] Freeman, A. M., III, The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, Council on Environmental Quality, Washington, D.C., 1979.

4.2 General Methodology: Case Study Streams Approach

A second approach to estimating the benefits of the effluent guidelines is to conduct detailed analyses of selected stream segments. We have taken relatively detailed water quality analyses of three river stretches, conducted by EPA's Office of Water Regulations and Standards as part of the Regulatory Impact Analysis, and applied "on-the-shelf" studies to estimate the value of the economic benefits that would be generated by the stated water quality improvements.

Recreation benefits for the case study streams have been estimated by the application of existing economic participation models and other techniques. These models combine information on the change in the availability of waters suitable for recreational activities with information regarding the socioeconomic profile of local populations. Based on this data, the models predict changes in the level of participation in certain recreation activities. For example, a projected improvement in water quality may be associated with the upgrading of a stream stretch from a rough fishing habitat to one that would support game fish such as bass. The increase in surface water acreage capable of sustaining a bass population is then weighted to account for locally available substitute sites. The resulting percentage increase in the supply of game fishing sites is then inserted into existing regression equations to predict the expected increase in local days spent bass fishing. The added participation days are then valued according to existing estimates of the average willingness to pay for each such activity day.

Nonuser benefits are also assigned to each stream on the basis of findings presented in published research. A number of studies of individual streams have determined that nonuser benefits of an improvement amount to roughly half of the increased recreational fishing value. This result is applied directly to each of the three case study streams. An alternate estimate of the nonuser benefits is derived by attributing shares of the aggregate benefit estimates for nonusers to each stream. The shares are based on the percentage of national polluted surface waters that each stream constitutes.

Human health, and diversionary uses and commercial fishery benefits have not been pursued vigorously for the case study streams. Human health effects were explored by identifying drinking water intakes along the affected stretches, and determining if the delivered tap water exceeded any existing federal standards. Because federal drinking water standards are not comprehensive, and because time and resource constraints prevented more extensive investigation of drinking water ingestion and other routes of exposure (such as fish consumption), we cannot be certain of the extent to which iron and steel plant effluent might contribute to adverse health effects along the case study streams.

No commercial fisheries were found along the streams, so no such benefits are presented. Nonetheless, the pollution in these streams might affect commercial fisheries located elsewhere. Also, improvements in water quality might induce such activities to locate along or downstream of the case study segments at some point in the future. We have been unable to include an analysis of such potential benefits.

Our estimates of the benefits of water quality improvements for the three case study streams are, we believe, as accurate as possible given the water quality assessments and given that time and resource constraints forced us to rely heavily on existing literature. Nonetheless, the three rivers provide a sample that is far too small to permit statistically sound extrapolation to all the affected waterways. The case study streams analysis yields interesting and reasonably valid information, but the sample is too limited to be used to evaluate the regulation as a whole.

4.3 Conclusion

As suggested by OMB, this economic benefit analysis of the proposed effluent guidelines uses "on-the-shelf" studies in an "experimental endeavor" to quantify and monetize the benefits expected to be realized due to projected changes in water quality. Throughout the report, we attempt to highlight all major assumptions and areas of uncertainty. Accordingly, most of our benefit estimates are presented as broad ranges. In this manner, we hope to contribute to the public body of useful information by prov

AN ECONOMIC ASSESSMENT OF THE BENEFITS OF THE FINAL EFFLUENT LIMITATION GUIDELINES FOR IRON AND STEEL MANUFACTURERS

Volume II: Allocating Shares of Estimates of the Aggregate Benefits of Water Pollution Control to the Iron and Steel Effluent Guidelines

May 1982
Office of Policy Analysis
U.S. Environmental Protection Agency

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SUMMARY

There are several published studies in which estimates of the national benefits of water pollution control have been derived. If these aggregate benefit estimates are reasonably accurate, and if a portion of the benefit figures can be attributed in a valid fashion to a given set of standards affecting a single class of industrial discharger, then one can obtain an estimate of the benefits of that specific regulation. Therefore, the primary foci of this study of the aggregate shares approach to benefit estimation have been to determine the validity and relevance of (1) existing aggregate benefit estimates, and (2) mechanisms by which portions of those benefits can be attributed to the proposed effluent limitation guidelines for iron and steel manufacturers.

Our analysis of the research efforts that have generated aggregate benefit estimates has determined that most of these studies are severely flawed. Accordingly, it would be inappropriate to base policy decisions on any single total benefit estimate. However, it is possible to use these studies to construct a broad benefits range that one can be modestly confident contains the correct figure. We have calculated that this range of the annual aggregate economic benefits to be derived from water pollution control is from $7.5 billion to $90.2 billion (1981 dollars). It must be emphasized that because of the limitations of the individual benefit studies, there is no objective analytical basis for selecting any one value within this range as being more likely than any other figure within the range. The estimates cited above represent the lower and upper bounds of what might essentially be considered a uniform distribution.

The problem of assigning portions of the aggregate benefits to the proposed BPT and BAT standards for iron and steel producers encompasses a series of highly complex issues. Use of the industry's share of total pollutant loadings to define such shares requires establishing an appropriate baseline and accounting for the variations in damages inflicted by the various categories of pollutants, in different bodies of water, affecting different aquatic and human populations. This implies that very intricate weighting schemes would be required to convert pollutant loadings into shares of benefits. Further, the method by which levels of effluent are converted to benefits must be consistent with the methodologies used in the models that generate aggregate benefit estimates. For these reasons, the sole reliance on simple percentages of pollutant loadings to define benefit shares could lead to errors of indeterminant direction and magnitude.

Despite the problems outlined above, we have relied on loadings share data in an experimental endeavor to attribute a portion of the aggregate benefits estimates to total pollution abatement in the iron and steel industry, and then to the BPT and BAT increments. Accordingly, the benefits of eliminating iron and steel industry effluent discharges, from 1972 baseline loadings, have been estimated to range from $320 million to $4.95 billion per year (in 1981 dollars).

The portion of the benefits attributable to moving from current treatment practicies to BPT are estimated to be $29.8 - $529.7

million per year (1981 dollars). The benefits of the movement from BPT and BAT are projected to be from $6.1 to $198 million annually (1981 dollars).

While is has been relatively straightforward to calculate these benefit figures on the basis of the industry's percentage share of discharge, we do not regard the resulting estimates with much confidence. This is due to the fact that (1) the aggregate benefits estimates may be highly imprecise, and (2) pollutant loadings are not sound proxies of economic benefits. Therefore, one should use extreme caution in interpreting results generated by the aggregate shares approach to benefits estimation.

1. Introduction

This analysis of the aggregate shares approach to estimating the benefits of industry specific effluent guidelines is divided into two sections. In the first section, a plausible range for the national benefits of water pollution control is derived. In the second section, issues concerning the appropriation of shares of the aggregate benefits to the proposed BPT and BAT guidelines for iron and steel manufacturers are discussed. Following these two sections, a sensitivity analysis and conclusions are provided. In addition, an appendix is attached in which Myrick Freeman discusses why it is inappropriate to derive sectoral benefit estimates from aggregate studies.

2. The Aggregate Benefits of Water Pollution Control

In 1979, Myrick Freeman[1] wrote a report[2] for the Council on Environmental Quality in which he reviewed studies that generated estimates of the total benefits to be derived from air and water pollution control. Freeman adjusted the studies to make them more consistent, and then used his professional judgment to synthesize aggregate benefits estimates of his own. The results of Freeman's review and synthesis, displayed in Table II-1, have attracted much attention as a possible means of evaluating the benefits of specific environmental policies. One of the primary objectives of this analysis of the benefits of the proposed effluent guidelines has been to review Freeman's estimates, as well as those from the studies underlying them, in order to determine whether they were (1) valid in the sense of being derived from sound data and appropriate analytical techniques, and (2) relevant for evaluating reductions in iron and steel discharges in terms of the sources and types of pollutants analyzed. The results of our analyses are summarized below according to four benefit categories described in Volume I of this report.

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[1] Professor of Economics, Bowdoin College.

[2] Freeman, A. M., III, The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, Council on Environmental Quality, Washington, D.C., 1979.

Table II-1

Myrick Freeman's Estimates of the
National Benefits of Water Pollution Control
(in billions of 1981 dollars per year)[a]

CATEGORY	RANGE	"MOST LIKELY ESTIMATE"[b]
Recreation	\$5.7 - \$19.5	\$9.5
Non User Benefits:	1.4 - 6.9	2.8
aesthetics, ecology, property values		
Diversionary Uses:	1.5 - 6.2	4.0
Drinking Water--Health Municipal Treatment Households Industrial Supplies		
Commercial Fisheries	.6 - 1.7	1.1
TOTAL	\$9.2 - \$34.3	\$17.4

SOURCE: Freeman, M., The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, December 1979.

[a] The benefit estimates have been updated from 1978 dollars by the Consumer's Price Index, which is consistent with Freeman's synthesis approach. The CPI figures for 1979 and 1980 are 12.7% and 12.6% respectively. A 9% CPI was used for 1981.

[b] Note, these estimates are based solely on Freeman's subjective judgment and cannot be considered to be expected values in any statistical sense.

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2.1 Recreation Benefits

a. Benefit Studies and Estimates

Recreation benefits are by far the most important category, accounting for more than half of the total benefits in Freeman's synthesis (see Table II-1). Freeman's recreation estimates essentially are based on four studies. Three of these studies, Unger (1975), Heintz et al. (1975), and Mills and Feenberg (1980), are based on the same extremely deficient set of data.[3] Freeman accordingly places little weight on these studies when deriving his own synthesis estimates, as may be ascertained from Table II-2.

The fourth set of benefit estimates Freeman cites are from a series of studies conducted for the National Commission on Water Quality (NCWQ). The Commission's fishing and boating estimates were based on an extensive study by the National Planning Association (NPA, 1975). While the NPA study avoids many of the data and conceptual pitfalls of the three efforts discussed above, it contains some other problems. First, the NPA study only predicts the increase in freshwater fishing and boating participation due to improvements in certain water quality parameters. The unit values assigned to each of these added activity days ranged from $14.00-$16.50 (1981 dollars). These values apparently were assigned by the Commission without any specified basis. The

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[3] These studies relied on limited data collected at only two sites. A more detailed analysis is provided in Freeman (1979).

Table II-2

National Recreation Benefit Estimates (in billions of 1981 dollars per year)

CATEGORY	STUDY:				
	Heintz, Hershaft, and Horak	Unger (DPRA)	Mills and Feenberg	National Commission on Water Quality[a]	Freeman (synthesis)
Fishing	2.5 - 10.4	3.5 - 20.9	14.4	6.3 - 7.4	3.6 - 12.4
Boating	1.4 - 7.2	1.5 - 10.4	2.6	1.7 - 3.9	1.7 - 3.9
Swimming	1.1 - 7.5	3.0 - 15.4	7.9	0.6 - 1.7	0.3 - 2.8
Water Fowl Hunting	0.1 - .6	0.1 - 1.0	0.7	------	0.1 - .4
TOTAL	5.1 - 25.7	8.1 - 47.7	25.6	8.6 - 13.0	5.7 - 19.5

SOURCE: Freeman, M., The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, December 1979.

[a] The NCWQ benefit figures, except for the marine sports component of fishing, have been doubled as done by Freeman to account for benefits associated with current levels of use.

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resulting benefit estimates therefore may be understated and somewhat arbitrary.[4] Further, the estimates pertain to only the value accruing to additions to participation, and thereby neglect the welfare gains to existing users due to the improved water quality. Freeman doubles the NPA estimates to account for this omission, however this is still likely to lead to underestimation of the total benefits (see Figure II-1). A similar adjustment was required for the Battelle Memorial Institute's estimates of swimming benefits for the NCWQ report.

In comparing the total recreation benefit estimates derived by Freeman relative to the estimates found in the underlying studies (see Table II-2), it is clear that Freeman discounted the high estimates more than the low ones. In part, this reflects a lack of confidence in the three studies yielding the relatively large upper bounds. Therefore, Freeman's range of $5.7 to $19.5 billion would seem to be reasonable. However, it should be noted that Freeman's reliance on NCWQ studies may tend to lead to a downward bias because of the relatively low unit values assigned by the NCWQ as well as the ad hoc, potentially conservative adjustment made by Freeman to account for the benefits associated with current levels of use. In addition, the benefit estimates exclude several popular forms of direct contact water-based recreation.

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[4] Empirical evidence yields fishing day values that range from $15-30 (Russell and Vaughan (forthcoming), and Charbonneau and Hay (1978)). A study conducted by the Sports Fishing Institute found that fisherman value a day of such recreation at over $80 (EPA Journal, May 1981). Note that the NCWQ values cited in the text have been adjusted for inflation.

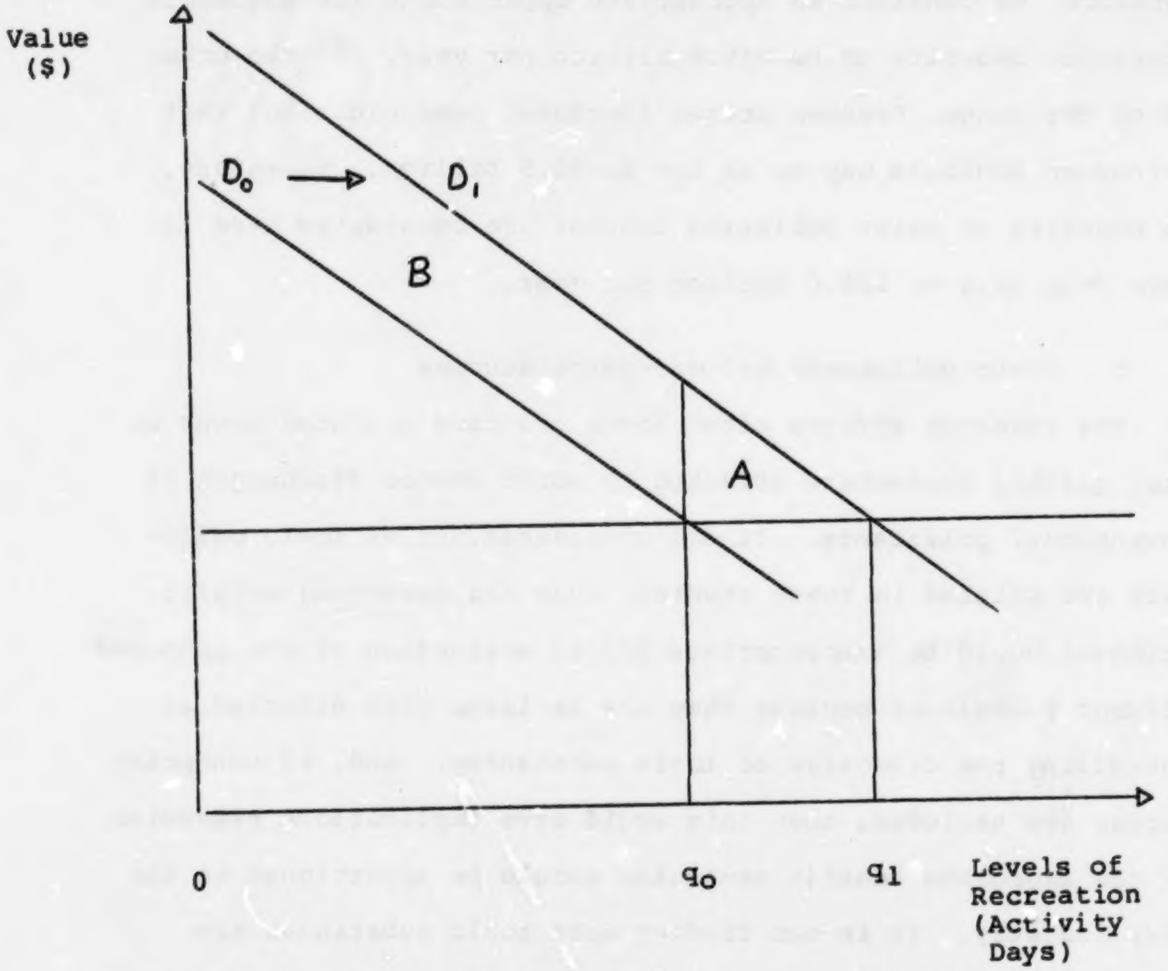
including sailing, canoeing, and water skiing. As a result, total recreation benefits could be considerably greater than stated. Therefore, we consider an appropriate upper bound for aggregate recreation benefits to be $25.0 billion per year. At the other end of the range, Freeman states (personal communication) that recreation benefits may be as low as $2.5 billion. Therefore, the benefits of water pollution control are considered here to range from $2.5 to $25.0 billion per year.

b. Toxic pollutants and non-point sources

The research efforts cited above all have a stated focus on water quality parameters affected by point source discharges of conventional pollutants. If all considerations of toxic pollutants are omitted in these studies, then the resulting benefit estimates would be inappropriate for an evaluation of the proposed effluent guidelines because they are in large part directed at controlling the discharge of toxic substances. And, if non-point sources are excluded, then this would have implications regarding how the aggregate benefit estimates should be apportioned to the steel industry. It is our finding that toxic substances are implicitly included in the water quality aspects of the recreation component of the benefit analyses, but that non-point discharges mostly are not.

The implicit inclusion of toxic substances occurs because the conventional pollutants are incorporated in the water quality models in such a manner as to serve as indicator pollutants. In essence, dissolved oxygen, turbidity, and other indices of

Figure II-1
Recreation Benefits of Water Quality Improvement



Water quality improvements shift the demand for recreation outward (D_o to D_1). As a result, the level of activity days increases from q_o to q_1. The benefits of added user days are measured by the consumer surplus represented by area "A". Area "B" reflects the benefits of water quality improvements with respect to existing levels of use. For the NCWQ studies that only measure A, Freeman doubles the benefit estimates (i.e., he assumes B = A). However, B may be several times greater than A, especially where increased use is small relative to prior use (as in water-based recreation). An analyses of the data used by Bouwes and Schneider (1979), revealed that B was slightly greater than four times A for the lake studied.

non-toxic pollution enter into the models as the only binding constraints on the recreational use of water bodies. When the removal of these pollutants is assumed to render the water fishable, this implies that any constraints posed by toxic substances have been relaxed as well. Therefore, the conventional pollutants serve as a proxy or indicator for all relevant point source discharges.

The damages of non-point sources of pollution are explicitly omitted from the major analyses cited by Freeman. This is because the water quality models appear to assess the damages inflicted only by point source discharges and, hence, the benefits of controlling those polluters. Non-point source pollution is omitted from the analyses in terms of the extent of water quality improvements. Therefore, only point sources are considered in the benefit shares allocation procedures discussed later in the report.

2.2 Nonuser Benefits

Nonuser benefits, as defined in Volume I, are difficult to quantify. And, because estimates of these benefits are often based on hypothetical valuation survey questionnaires, there is a potential for error and bias. Therefore, a wide range must be constructed for nonuser benefits.

Myrick Freeman derived his "most likely" estimate of nonuser benefits by simply assuming that they would approximate fifty percent of his recreation fishing benefits. This procedure was based on the results of three surveys[5] that found nonuser benefits to amount to 53%, 54%, and between 50% and 150% of fishing benefits along specific rivers. Accordingly, Freeman's range for nonuser benefits in 1981 dollars is from $1.4 to $6.9 billion annually.

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[5] Walsh, R., et al. (1978), Meyer (1974), and Horvath (1973).

Since Freeman completed his study, another major effort to estimate nonuser benefits has been undertaken by Mitchell and Carson[6]. This study, based on a national survey of over fifteen hundred households, yields an average willingness to pay for fishable waters by nonusers of $121 per household. This implies aggregate benefits amount to $11.1 billion annually.[7] While hypothetical valuation surveys often are suspected of yielding values that are greater than what individuals would pay in a market, Mitchell and Carson treated zero bids in such a manner as to make their results as conservative as possible.

Because of the uncertainty surrounding estimates of nonuser benefits, and because of the new evidence provided by recent research, we have expanded the Freeman range of nonuser benefits to $0.7 to $12.0 billion annually. In view of the fact that the benefits derived from Mitchell and Carson utilize their average estimate bid, the upper bound we assign of 12.0 is a conservative one. The lower bound revision is based on Freeman's reassessment of the CEQ estimates (personal communication).

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[6] Mitchell, R., and Carson, R., An Experiment in Determining Willingness to Pay for National Water Quality Improvements, Resources for the Future (forthcoming).

[7] Walsh, et al. (1978), derive a bid of over $66.45 for non user households, implying aggregate benefits of $6.1 billion annually. One reason why Mitchell and Carson found higher bids may be because they include near-stream activities such as picnicking and hiking as intrinsic benefits, and only consider direct contact, in-stream activities as recreation. This distinction is often blurred in benefit studies, leading to inappropriate comparisons of different benefit estimates. The Mitchell and Carson definitions of recreation and non user benefits are consistent with the ones used throughout this analysis.

2.3 Human Health Benefits

Myrick Freeman's range for human health benefits, from $4.1 million to $2.8 billion per year, pertain only to bacterial diseases related to drinking water drawn from surface supplies. To obtain a more complete health benefits estimate, one also must include (1) the impacts of toxic chemcials on health through ingestion of surface drinking water, (2) all pollution-related health impacts related to groundwater ingestion, (3) consideration of the effects of ingestion of contaminated fish and other aquatic foods, and (4) an assessment of risk posed by dermal exposure to polluted water by way of direct contact.

There are several studies that have addressed the first issue noted above by estimating the excess risks of cancer resulting from ingestion of surface water drawn from polluted rivers. These studies may be used to estimate a portion of the health value of abating water pollution. Page, Harris, and Epstein (1976) found evidence linking contamination of surface drinking water supplies with higher cancer mortality, attributing one in every seven cancer deaths in males to drinking water drawn from the lower Mississippi River. Cornell, et al. (1981)[8] translate this to an excess lifetime cancer risk of 1400 per 100,000, which means that for every thousand lifetime exposures, fourteen fatalities would be expected due to cancer caused by drinking water drawn from polluted surface supplies. Applying this risk factor to the population served by surface water supplies,[9] one obtains 2,193,800 excess cancer fatalities per lifetime, 31,340 per year. Assigning a value for each "statistical life" saved of $3 million,[10] one obtains an annual benefit estimate of $94 billion for eliminating nonbacterial contamination of surface water.

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[8] Cornell, N., Myslinski, and Pelcovits, "Cost/Benefit Analysis of EPA's Proposed BAT Effluent Guidelines Limitation On Iron and Steel Manufacturers," August 1981. This study was sponsored by the American Iron and Steel Institute.

A study by Page, Harris, and Reiches (1977) of the Ohio River Valley associated approximately 980 cancer deaths per 100,000 using surface drinking water. A second Ohio study, by Buncher, Kurma, and Forcade (1977), implies a lifetime excess cancer risk of 910 per 100,000. Using the latter risk assessment and a value of statistical life of 2.0 million, one obtains an annual health benefit of $41 billion. Cornell, et al., citing the three studies above, uses a lifetime risk of 700 per 100,000 and a value of life of

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[9] 156.7 million people are served drinking water drawn from surface water sources according to the Federal Reporting Data System, Office of Drinking Water, U.S. EPA. Due to aggregation error, this figure may be overstated by roughly ten percent, yielding an exposed, population of 141 million.

[10] There is extensive literature on the values of reducing risks of fatality, i.e., the value of what might be called a "statistical life." The range of values often cited is from $300,000 to $2.5 million. The $3 million used follows the recommendation by Page (personal communication) that such a relatively high value be assigned for painful and dreaded cancer deaths. It should be noted that the range of values cited above pertain to voluntary, compensated risks and, therefore, may understate the life values associated with involuntary and uncompensated exposure to risk. Some of the estimates are also derived from individuals who probably are not as averse to risk as the population as a whole.

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$1.66 million,[11] resulting in an annual benefit estimate of $26.0 billion. If the risk level and life values used by Cornell, et al. were each halved, one would obtain a benefit figure of $6.5 billion. These and similar calculations are presented in Table II-3. It is clear that estimates of health benefits are extremely sensitive to the risk factors and dollar values for lives saved that are used.

From the review above of estimated health benefits derived from alternate risk factors and values per cancer fatality avoided, it appears reasonable but conservative to construct a range of the nonbacteria-related drinking water health benefits of controlling surface water pollution of $2.0 to $45 billion.[12] However, it should be noted that these figures could be misstated for a variety of reasons. First, the potential for aggravating synergistic effects is not considered. Second, the cancers detected in the three studies would be the result of carcinogens ingested up to twenty or forty years ago. A greater (or lesser) level of carcinogens may be discharged today, implying a greater (or lesser) number of future cancers. Third, some of the carcinogens may not be the result of industrial discharges. Fourth, the benefits above relate to only cancers and overlook potential heart, liver, or other noncarcinogenic ailments that could result from nonbacterial contamination of water supplies. And fifth, the macro epidemiological studies generating the risk levels are, in essence, unverifiable and, therefore, of unknown reliability.

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[11] Cornell, et al. assign $1.38 million for each life saved, plus $0.28 million for reduced morbidity, yielding a total of $1.66 million per cancer avoided.

[12] Note that an upperbound of $45 billion is selected rather than the $94 billion that can be derived from the Page, Harris, and Epstein study. This is intended to reflect the fact that most surface water supplies are not as polluted as the lower Mississippi and Ohio Rivers.

Combining Freeman's health benefits for waterborne diseases with the surface drinking water cancer benefits range established above, one obtains an aggregate health benefits range of $2.0 to $47.8 billion annually. Again, these may be conservative estimates in that the benefit figures do not include the health effects associated with the ingestion of groundwater or aquatic foodstuffs tainted by surface water discharges, nor do they incorporate the benefits of reduced risks of harm by way of dermal exposure.

2.4 Diversionary Uses and Commercial Fisheries

a. Municipal Water Supplies

Freeman's estimate of the treatment cost savings that would accrue to muncipal water supplies due to the control of point source discharges is from $.8 to $1.7 billion. These figures are based solely on the elimination of treatment required to remove suspended solids and substances affecting odor and taste, and are derived from studies[13] that indicate the costs of municipal water

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[13] Unger (1976), and Heintz *et al*. (1976), refer to the following studies for the 40% cost savings estimate: Bramer, H. C., *Economic Aspects of the Water Pollution Abatement Program in the Ohio River Valley*, 1960, and Barker and Kramer, "Water Quality Conditions in Illinois," *Statewide Water Resource Development Plan*, Illinois Department of Transportation, 1973.

Table II-3

Annual Health Benefits of Removing Carcinogens from Surface Drinking Water Supplies

Risk Assessment		Value per Cancer Avoided (billions of 1981 dollars)			
Excess cancers per lifetime exposure	Annual cancer fatalities[a]	$0.0005	$0.001	$0.002	$0.003
350×10^{-5}	7,835	3.9	7.8	15.6	23.4
700×10^{-5}[b]	15,670	7.8	15.6	31.2	46.8
900×10^{-5}	20,147	10.0	20.2	40.3	60.5
1400×10^{-5}[c]	31,340	15.7	31.4	62.8	94.2

[a] Derived by applying risk assessments to an exposed population of 157 million. If this population is overstated due to aggregation error (see footnote 9), the benefits estimates above would range from $3.5 to 84.8 billion per year.

[b] Risk assessment applied by Cornell *et al*. (1981)

[c] Risk assessment derived from Page, Harris, and Epstein (1976).

supply treatment would be reduced by 40% if the relevant discharges were controlled at the source. Freeman's benefit estimates therefore omit treatment costs that are related to a broad range of water pollution problems. The 40% cost savings should also be considered as potentially erroneous.

In order to incorporate some of the municipal water supply cost savings expected to result from reduction in effluent other than suspended solids, it is assumed that 40% of the expected increase in treatment resulting from compliance with the Interim Primary Drinking Water Regulations (IPDWR)[14] could be eliminated with improved point source controls. Accordingly, $154[15] million are added to Freeman's upper and lower bound benefit estimates. This yields an aggregate benefit range of $1.0 to $1.9 billion per year. Again, it should be noted that the assumption of a 40% cost savings may be erroneous. Also, the IPDWR as promulgated in 1975 are not complete; additional contaminants originating from point source discharges may be identified, thereby leading to additional treatment requirements for water supplies. The estimated IPDWR compliance costs therefore do not represent the full amount of municipal supply treatment costs.[16/]

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[14] The IPDWR, as promulgated in 1975, in accordance with the Safe Drinking Water Act, sets maximum contaminant levels for arsenic, barium, cadmium, chromium, flouride, lead, mercury, nitrate, selenium, silver, turbidity, coliform bacteria, and several organic contaminants. Compliance is mandated for 1984.

[15] The costs of IPDWR compliance have been estimated at $1.34 billion in capital expenditures (1981 dollars) and $170 million in annual operation and maintenance costs (U.S. EPA, Water Utility Financing Study, Volume I, August 1980). The total annualized costs therefore are $384 million when capital expenditures are financed at a 15% interest rate over a twenty year period.

An important consideration regarding the benefits of reduced water supply treatment costs is that they can be inversely related to human health benefits. The cancer deaths projected in the previous section of the report might be reduced substantially if more extensive water purification occurred. If such drinking water treatment devices were to be installed, then the benefits of point source discharge controls would be the portion of such costs avoided rather than the cancer cases and other illnesses prevented.

b. Industrial and Household Use

The studies that Freeman cites for deriving estimates of household and industrial benefits of point source discharge controls pertain to only the damages associated with mineral contamination (hardness and dissolved solids). Therefore, Freeman's annual benefit estimate range of $0.7 to $1.8 billion are understated as they fail to account for damages inflicted by toxic substances and other pollutants. There are no data available to

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[16/] For example, standards have also been set for trihalomethanes (THMs), expected to cost $20.7 million annually in 1981 dollars, with $11 million in operation and maintenance and capital outlays of $92.7 million (Office of Drinking Water, U.S. EPA). THMs are carcinogens that result when chlorine, added to water as a disinfectant, reacts with naturally occurring organic compounds. While these natural components are not attributable to point source discharges, the chlorination process itself may be required because of water pollution. Reductions in certain discharges might, therefore, result in reduced chlorination. This, in turn, would reduce THM formation and the accompanying cancer risks and/or treatment costs.

correct for these omissions. We, therefore, use Freeman's estimated range with the understanding that it probably is biased downward.

c. Commercial Fisheries

Freeman estimates that the value of the benefits to commercial fisheries due to control of point source discharges would be between $0.6 to $1.7 billion annually. These figures primarily are based on a study by Bell and Canterbery (1975) for the National Commission on Water Quality. In essence, Freeman simply adds $100 million (1978 dollars) to the Bell and Canterbery results to account for their omission of freshwater fisheries benefits and damages avoided due to chemical contaminants. This adjustment may be somewhat unscientific, but given a lack of relevant information, no other correction is more or less defensible.

d. Conclusions

Diversionary uses (non-health related) and commercial fisheries benefits are given a combined range of $2.3 to $5.4 billion annually. These estimates virtually are lifted directly from Myrick Freeman's work,[17] and are somewhat arbitrary and might well be understated for the reasons cited above.

2.5 Other Benefits of Pollution Control

Pollution controls can generate benefits other than noted in the benefit categories discussed above. These include resource recovery and technical innovation. While it is not possible here to predict levels of such potential benefits, there might be instances in which such benefits will be substantial.[18]

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[17] In 1981 dollars, Freeman's benefit range is $2.1 to $5.2 billion annually for these benefit categories.

2.6 Conclusions

Through indepth analyses of Freeman's national benefits synthesis estimates, and of the individual research studies underlying them, we have concluded that such benefits estimates are based on very limited scientific and economic data and, consequently, are of questionable validity. It has also been determined that these estimates omit damages from nonpoint source discharges. Further, in some benefit categories, the existing benefit figures do not reflect the impact of all relevant classes of pollutants, nor all the channels by which pollutants may inflict damage. Nonetheless, we have attempted to construct a range that we believe establishes reasonable bounds for the aggregate benefits of water pollution control.

The range of aggregate benefits of water pollution control is projected to be from $7.5 - $90.2 billion annually in 1981 dollars. This range is comparable to the range established by

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[18] An example may be found in the electroplating industry. Water pollution controls mandating recycling have led in some instances to a recovery of large quantities of chrome that previously had been discharged as waste. As a result of the reuse enabled by the pollution controls, one firm has reported that it purchases roughly 10% of the chrome that it would have had to purchase otherwise. The system is expected to pay for itself ($30,000) in two and a half years because of the savings of water and raw materials ("Regulatory Cloud Has a Silver-Plated Lining," The Washington Post, July, 6, 1981, p. A13).

Myrick Freeman when adjustments are made for the potential carcinogenic health impacts of drinking water tainted by industrial discharges. The benefits estimates are summarized and compared in Table II-4. Throughout the text of this report, we have attempted to state clearly the limitations and potiential biases and omissions in these calculations. The broadness of this range reflects the uncertainty and lack of confidence in preexisting aggregate benefits research. It is our firm conclusion that due to the uncertainty of these benefit estimates, it would be inappropriate to draw a single point estimate from the projected range. There is no sound, objective, analytical basis for selecting an average or most likely estimate. We also believe that there is no valid evidence available at this time to support a substantial narrowing of the range of benefits.

Table II-4

The National Benefits of Water Pollution Control
(billions of 1981 dollars per year)

Benefit Category	Freeman's Range[a]	Freeman's Range as Adjusted by EPA[b]
Recreation	$5.7 - 19.5	$2.5 - 25.0
Nonuser	1.4 - 6.9	0.7 - 12.0
Human Health[c]	0.0 - 2.8	2.0 - 47.8
Diversionary Uses	1.5 - 3.5	1.7 - 3.7
Commercial Fisheries	0.6 - 1.7	0.6 - 1.7
TOTAL[d]	$9.2 - 34.3	$7.5 - 90.2

[a] Freeman, M., The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, CEQ, December 1979.

[b] All adjustment are described in the preceeding text.

[c] The large difference in the ranges of human health benefits is due to the inclusion of carcinogens in the EPA analysis (see text).

[d] If health benefits are omitted from the totals, the ranges are very comparable: Freeman would have $9.2 - $31.5 billion, and EPA would have $5.5 - $42.4 billion.

3. Attributing Shares of Aggregate Benefits to Effluent Guidelines for Iron and Steel

Given a range of the aggregate benefits of water pollution control, what shares might be attributed to iron and steel industry compliance with the proposed BPT and BAT effluent limitation guidelines? There is a natural inclination to answer this question strictly by using the industry's percentage of pollutant loadings relative to aggregate discharge levels. However, there are a number of difficulties with this approach. First, there is the issue of defining the appropriate loadings baseline. Second, loadings data are sorely lacking for certain types of pollutants and dischargers.

A third, and perhaps the most important flaw with relying strictly on loading shares to define benefits is that this approach fails to account for for all the key factors that determine how loadings are related to environmental damages and, hence, benefits. For example, one pound of toxic pollutant will inflict a different level of damage than will a pound of conventional pollutant, even if both are discharged into the same river. Also, a pound of one given pollutant will cause different damages in one water body than it will in another because of differences in flow, temperature, and so forth. Further, the removal of one pound of any specific pollutant from each of two identical streams will result in different levels of benefits depending on who might use the water and on the condition and availability of substitute sites.

A fourth problem with assigning benefit shares on a loadings reduction basis is that the implied linear relationship between pollution and benefits is inconsistent with the water quality models and underlying biological dose-response functions used to derive the national benefits estimates. It is inappropriate to divorce the share allocation procedure from these underlying relationships. Myrick Freeman stresses this point in a paper entitled "On Deriving Sectoral Benefits Estimates from National Aggregate Studies," which is included in the appendix. If the conversion of effluent reductions into benefits is not consistent with the methodologies used to generate the aggregate benefit estimates, then errors of indeterminant direction and magnitude might arise.

Despite the four basic problems outlined above, we proceed in this section of the report to attribute a portion of aggregate benefits to total pollution abatement in the iron and steel industry, and then to the BPT and BAT increments, solely on the basis of available loadings data. While the shortcomings of this approach greatly diminish our confidence in the results of the analysis, we believe that the broad benefits range we present is illustrative and contributes some useful information.

3.1 The Iron and Steel Industry's Share of Total Point Source Loadings

The iron and steel industry contributes a large portion of total industrial and municipal discharge. The appropriate pollutant loadings data to use in calculating the industry's loadings as a percentage of total point source discharges would be based on 1972 after treatment discharges for all pollutants. The 1972 figures are relevant because that year serves as the baseline of the benefit analyses that have generated the aggregate estimates.

Nonpoint source loadings need to be accounted for as well in those instances they were relevant in calculating existing benefit estimates.[19]

Because aggregate loadings data are not readily available for 1972, nor for all pollutants, we have had to rely on 1968 discharges for conventional substances, and more current (i.e., projected BPT) loadings of selected toxics. The assumption is that the iron and steel industry's share of total point source discharges in 1972 is reflected accurately in data from other years. The industry's share of loadings of conventional pollutants is calculated and presented in Table II-5. Accordingly, the industry is shown to be responsible for 7.0% of the pounds of these pollutants discharged from point sources.

In Table II-6, the industry loadings share is presented for selected toxic pollutants. It should be noted that the consideration of toxic loadings raises several issues. First, there is limited information concerning discharges of toxic substances. This constrains the analysis to the few substances listed in Table II-6. Second, the limited loadings information shown reflects projected discharges after full BPT compliance across all industrial categories. These data, therefore, are less relevant than 1972 or

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[19] Nonpoint source contributions to pollution damages appear to be included in the commercial fisheries, human health, and diversionary uses benefits research used by Freeman. Recreation and nonuser benefit estimates are, for the most part, restricted to point souce impacts. However, nonpoint sources may have been included implicitly in some of the minor, site-specific recreation studies cited by Freeman. The major aggregate studies he cites (i.e., Unger, Henitz et al., and the National Commission on Water Quality) were based on water quality models that were scaled explicitly so as to exclude nonpoint source damages.

Table II-5
The Iron and Steel Industry's Share of Conventional Point Source Loadings[a]
(millions of pounds discharged annually)

Pollutant	Direct Industrial Discharges	Municipal Discharges	Total Point Source Discharges	Iron & Steel Discharges[b]	Iron & Steel's Share of Total
Total Suspended Solids (TSS)	1,733	1,250	2,983	278	9.7%
Chemical Oxygen Demand (COD)	3,455	2,183	5,638	508	9.0%
Biological Oxygen Demand (BOD)	1,804	1,250	3,054	76	0.8%
TOTALS	6,992	4,683	11,675	811	7.0%

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[a] Loadings reflect 1968 discharge levels, derived from Research Needs and Priorities: Water Pollution Control Benefits and Costs, Vol. II, Table A-5, EPA 600/5-73-0086, October 1973.

[b] Iron and steel loadings based on the industry's shares of primary metals loadings, by pollutant category, from Council on Environmental Quality, Environmental Quality, First Annual Report, August 1970.

current toxic loadings. And, because the iron and steel industry has yet to attain the BPT level of abatement, the 6.0% loadings share derived in Table II-6 may very well understate the industry's present and historic contribution to toxic water pollution.20/ Nonetheless, the 6.0% toxics share figure is weighted equally with the 7.0% conventional share from Table II-5. Accordingly, the industry's share of point source pollution loadings is defined here to be 6.5%.

3.2 Accounting for Nonpoint Source Impacts

Although Myrick Freeman asserts that the cited aggregate benefit estimates pertain only to the abatement of point source discharges21/, there appears to be some benefit categories in which the benefits of nonpoint source pollution control have been incorporated.22/ Therefore, a mechanism is required to apportion the aggregate benefits estimates between point and nonpoint sources in order to then allocate a share of the latter to the iron and steel industry.

Determining the relative damages of point and nonpoint source pollution is highly problematic. There are some estimates of the relative magnitude of point and nonpoint source loadings for a few

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20/To illustrate this point, consider that at full BPT compliance across all iron and steel facilities, toxic discharges would be reduced by 65% from current loadings.

21/Freeman, A. Myrick III, op. cit., page x.

22/Nonpoint source damages appear to be relevant in the estimates of human health, diversionary uses, and commercial fisheries benefits. However, for recreation and, consequently, nonuser benefits, nonpoint sources are incorporated vaguely, if at all (see footnote 19 for a more detailed discussion).

Table II-6

The Iron and Steel Industry's Share of Point Source Discharges of Selected Toxics[a]
(metric tons annually, in pound equivalents)

Toxic	Water Quality Criteria Weight[b]	Total Point Source Discharge (Pound Equivalents)[b]	Iron and Steel Discharge	%
Cynaide	1.6	8,802	632	7.2%
Lead	1.5	2,292	83	3.6%
Zinc	.12	1,112	27	2.4%
Chronium	.13	248	8	3.0%
TOTAL	--	12,454	750	6.0%

[a] Projected at full BPT compliance for industrial sources and secondary treatment for all municipal dischargers. This projection scenario may misstate the iron and steel industry's 1972 (or current) share of toxic discharges.

[b] Pound equivalents are equal to actual pounds discharged times the water quality criteria weight. The weights are equal to the inverse of each substance's water quality criteria, normalized relative to the toxicity of copper.

pollutant categories. These data indicate that nonpoint sources contribute significantly greater loadings than do point sources for some substances. For example, over eighty percent of suspended solids may originate from nonpoint sources. However, it does not follow that industrial, municipal and other point source discharges account for less than twenty percent of water pollution damages. According to the National Water Quality Inventory, such loadings data cannot be used as the sole criteria for assessing the relative impacts of nonpoint and point sources:

> Nonpoint sources, in contrast to point sources, are generally diffuse and may be more readily assimilated by the receiving waters than the more concentrated point source loads. In addition, nonpoint loads are generally released as pulse loads during rainfall events, and any associated violations of water quality standards may be of an intermittent rather than continuing nature.[23]

An alternative approach to determining relative water quality impacts across sources may be found in the States' assessments of 239 hydrological basins. Of these basins, 219 were cited as having water quality problems related to point source discharges, and 207 were listed as adversely affected by nonpoint loadings (most basins being affected by both sources).[24] These figures indicate that 48.6% of the water quality impacts were nonpoint source related (207 / [207 + 219]). Because the approach outlined above fails to account for the relative intensity or perseverance of the water quality problems, it is likely that the 48.6% figure would overstate the actual share of damages attributable to nonpoint sources. Consequently, assigning the remaining 51.4% to point sources would result in a lower bound estimate of the aggregate benefits of controlling pollution from that sector. By reducing the nonpoint allocation by two thirds, a point sources share of 84.0% is derived. This figure will be used below to approximate the upper bound benefit share for the abatement of pollution from point sources.

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[23] U.S. Environmental Protection Agency, National Water Quality Inventory, 1977 Report to Congress, EPA-440/4-78-001, October 1978, p. 18.

[24] Ibid.

In Table II-7, estimates of the aggregate benefits of controlling water pollution from point sources alone are presented. These figures have been derived by applying the percentage shares discussed above to the aggregate benefits estimates, from Table II-4, as appropriate for each category. This implies that for recreation and nonuser benefits, in which nonpoint impacts have been excluded for the most part, the share alloted to that source has been reduced accordingly. The benefits of moving from 1972 levels of pollution to elimination of discharge across all point sources is estimated by this method to range from $4.9 to $78.5 billion annually.

3.3 The Iron and Steel Industry's Share of Aggregate Benefits

The benefit estimates derived above, and presented in Table II-7, pertain to the value of reducing all point source pollution from conditions existing in 1972 to those mandated for 1985 -- namely total elimination of discharge. Utilizing the loadings share methodology, 6.5% of these aggregate benefits would serve as an approximation of the benefits of controlling iron and steel

Table II-7

The Aggregate Benefits of Controlling Point Source Water Pollution
(billions of 1981 dollars per year)

Benefits Category	Percentage Share Attributed to Point Sources[a]	Annual Point Source Aggregate Benefits[b]
Recreation	84.0 - 94.7[c]	2.1 - 23.7
Nonuser	84.0[d]	0.6 - 10.1
Human Health	51.4 - 84.0	1.0 - 40.2
Diversionary Uses	51.4 - 84.0	0.9 - 3.1
Commercial Fisheries	51.4 - 84.0	0.3 - 1.4
TOTAL	---	4.9 - 78.5

[a]/Described in text.

[b]/Derived by multiplying percentage shares times benefits ranges from Table II-4.

[c]/Due to the general exclusion of nonpoint impacts in major studies estimating recreation benefits, that source's shares is calculated as one third the amounts shown for other categories.

[d]/The lower bound nonuser estimate is based on recreation findings, while the upper bound was estimated independently (Mitchell and Carson). Hence, the 84.0 share is applied to both the lower and upper estimates.

industry discharges alone.[25] As shown in Table II-8, this indicates that moving the industry from 1972 pollution levels to zero discharge would result in benefits ranging from $320 million to $4.95 billion per year.

3.4 The Benefits of BPT and BAT in the Iron and Steel Industry

The range of benefits derived above, and presented in Table II-8, pertain to the value of moving from the 1972 level of discharge by the industry to total elimination of discharge. To calculate the benefits of the BPT and BAT treatment scenarios on the basis of loadings shares, the incremental pollutant removal for both technologies must be calculated as percentages of 1972 baseline loadings.

In Tables II-9 and II-10, the relevant loadings data and pollutant removal shares are presented. Moving from current treatment practices to industry-wide compliance with BPT would remove 10.7% of the toxic substances, and 9.2% of the other pollutants relative to 1972 loadings.[26] Movement from BPT to BAT would remove an additional 4.0% of the toxic organics and metals, and 1.9% of the conventional pollutants. In Table II-11, these loadings reduction shares are applied toward the benefits estimate range for total elimination of discharge. The resulting benefit estimates for BPT and BAT are summarized in Table II-12. BPT benefits range from $29.8 million to $529.7 million per year, and the annual benefits of BAT are estimated at between $6.1 and $198 million.

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[25] The 6.5% industry share figure was derived in Section 3.1, see especially Tables II-5 and II-6.

[26] These percentage removed figures are calculated as: current loadings minus BPT loadings, divided by 1972 loadings.

Table II-8

Annual Benefits Attributable to Iron and Steel Zero Discharge[a]

(billions of 1981 dollars per year)

Benefit Category	Lower Bound	Midpoint	Upper Bound
1. Recreation	$0.14	$0.84	$1.54
2. Nonuser	0.04	0.35	0.66
3. Diversionary Uses and Commercial Fisheries	0.08	0.19	0.29
4. Human Health[b]	0.07	1.26	2.46
TOTAL[c]	$ 0.32	$ 2.64	$ 4.95

[a] Relative to 1972 levels of discharge. Estimates derived from Tables II-5, II-6, and II-7.

[b] For human health, the aggregate benefits due to bacterial disease control have been excluded as they are not relevant to industry discharges.

[c] Totals may not add due to rounding.

Table II-9

Iron and Steel Industry Loadings: 1972 Baseline, Current (1981) and at BPT and BAT

(long term average tons per year)

	Raw Waste	1972[a]	1981	BPT	BAT
Toxic Organics	42,400	12,500	2,410	720	133
Toxic Metals	132,300	9,200	1,180	556	279
Other Pollutants[b]	14,710,000	660,000	105,000	44,012	31,722
TOTAL	14,884,700	681,700	108,590	45,288	32,134

[a] 1972 loadings are based on facilities now in operation, and have been calculated according to treatment in place at that time.

[b] Other pollutants include: TSS, oil and grease, ammonia, sulfide, phiocynate, and fluoride.

Source: Gary Amendola, Senior Iron and Steel Specialist, OWRS, U.S. EPA, October 1981.

Table II-10

Pollutant Removals by BPT and BAT Relative to 1972 Discharge Levels
(tons per year and percentage removal)

Pollutant Category	1972 discharges for iron and steel	Removal as of 1981[a]		Incremental BPT Removal[a]		Incremental BAT Removal[a]	
		tons	%	tons	%[b]	tons	%[b]
Toxic Organics	12,500	10,090	80.1%	1,690	13.5%	587	4.7%
Toxic Metals	9,200	8,020	87.2%	624	6.8%	277	3.0%
SUBTOTAL	21,700	18,110	83.5%	2,314	10.7%	864	4.0%
Other Pollutants[c]	660,000	555,000	84.1%	60,988	9.2%	12,290	1.9%
TOTAL	681,700	573,110	84.1%	63,302	9.3%	13,154	1.9%

[a] Calculated from data reported in Table II-15.

[b] Incremental percentage removals are calculated from the 1972 baseline.

[c] The other pollutants category consists of suspended solids, oil and grease, ammonia, sulfide, phiocynate, and fluoride.

Table II-11

Annual Benefits of Iron and Steel BPT and BAT
(millions of 1981 dollars)

Treatment	Percent Removal	Lower Bound	Upper Bound
All Pollutants:			
1972 to Total Abatement[a]	100%	$320.0	$4,950.0
All Pollutants:			
Current to BPT:	9.3%	29.8	460.4
BPT to BAT:	1.9%	6.1	94.1
Toxic Pollutants			
Current to BPT:	10.7%	34.2	529.7
BPT to BAT:	4.0%	12.8	198.0

[a] From 1972 loadings to zero discharge, from Table II-8.

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Table II-12

Annual Benefits of BPT and BAT
(millions of 1981 dollars)

Treatment Scenario	Benefits Range[a]		
	Lower Bound	Midpoint	Upper Bound
Current to BPT	$ 29.8	$ 279.8	$ 529.7
BPT to BAT	6.1	102.1	198.0

[a] Derived from results shown in Table II-11.

4. Sensitivity Analysis

The limitations of the shares of aggregate benefits approach have been discussed throughout this report. In part, uncertainties concerning the validity of the national benefit estimates, the accuracy of loadings data, and the role of nonpoint source contributions call into question the accuracy of the benefits estimates derived above for BPT and BAT. In this portion of the report, alternate national benefit and pollutant loadings figures are applied to the analysis to illustrate the extent to which the results of the analysis are sensititive to these scenarios.

The results of the sensitivity analysis are provided in Table II-13. Scenario 1 represents the results of the primary benefits assessment described in the preceeding text and tables. Scenarios 2, 3, and 4 illustrate the impact of using different aggregate benefit estimate ranges on the BAT benefit figures. The upper bound benefits are somewhat more volatile across scenarios then are the relatively stable lower bound estimates. This suggests that these latter figures indeed may be viewed as lower bounds with a moderate degree of confidence.

Scenarios 5 and 6 incorporate different assumptions regarding the allocation of benefit shares on the basis of loadings data. In the fifth scenario, nonpoint source pollutant loadings are deleted from the baseline from which the iron and steel industry's share of aggregate benefits is determined. This is in line with Freeman's assertion that the aggregate benefit estimates involve the impacts of controlling only point source pollution. In Scenario 6, the share of benefits attributable to BAT are calculated according to toxics removal alone, conventional pollutants being excluded. The remaining scenarios in Table II-13 illustrate the effect combinations of different assumptions have on the benefit estimates. According to this sensitivity analysis, it appears unlikely that the annual benefits of BAT would be less than $5 million or greater than $225 million. However, because this sensitivity analysis can not correct for the potential errors generated by the assumption that benefits are strictly proportional to loadings, the benefits ranges must still be interpreted with a great deal of caution.

Table II-13

Sensitivity Analysis: BAT Benefit Estimates Under Alternate Scenarios
(millions of 1981 dollars)

Scenario	Benefit Estimate Range	
1. No change (Table II-12)	$6.1	$198.0
2. Delete Nonuser Benefits Entirely	5.3	171.6
3. Delete Health Benefits Entirely	4.8	99.6
4. Use Freeman's Aggregate Benefits Range[a]	8.8	80.9
5. Delete Nonpoint Sources from Baseline Aggregate Benefits	9.3	227.2
6. BAT share defined by Toxics Control only	12.8	198.0
7. Scenarios 2 and 6 combined	11.2	171.6
8. Scenarios 3 and 6 combined	10.0	99.6
9. Scenarios 4 and 6 combined[a]	18.5	80.9
10. Scenarios 5 and 6 combined	19.5	227.2

[a] Recall that Freeman's estimates did not include the full range of human health effects. Therefore, Scenarios 3 and 4 are similar at their upper bounds.

5. Conclusions

It has been a relatively straightforward exercise to calculate the benefits of BPT and BAT for the iron and steel industry by allocating shares of the national benefits of water pollution control on the basis on percentages of discharge. However, the resulting benefits estimates should not be regarded with much confidence. This lack of confidence stems from two basic flaws in the approach: (1) The reliance on national benefit estimates that are suspected to be imprecise, and (2) The use of loadings data to allocate shares of the aggregate benefits to the iron and steel industry, and then to BPT and BAT within the industry.

The aggregate benefit estimates may be imprecise for several reasons. In some instances, the effects of relevant pollutants (notably, toxics) are omitted, and in many important cases the impacts of nonpoint pollution are not incorporated. More importantly, the underlying studies generally are based on weak water quality models and severely limited data. Therefore, at best, aggregate benefit estimates may be used to suggest a broad range of national benefit values.

The use of pollutant loadings data creates two problems -- the first is that the loadings data that are available are incomplete and possibly imprecise, and the second is that loadings are extremely poor proxies for benefits. Benefits are determined by factors such as the hydrology of the affected water bodies, socioeconomic characteristics of the surrounding population, dose-response functions, and relative toxicities of pollutants. Loadings data fail to account for these factors, and using them to define benefit shares might generate errors of unknown direction and magnitude.

In recognition of the problems outlined above, we have attempted to construct a broad range of benefits for the effluent guidelines proposed from iron and steel manufacturers. The breadth of this range, coupled with the results of the sensitivity analysis, leads to a moderate degree of confidence that the actual benefits figure would lie within the estimated bounds. However, due to the analytical shortcomings embodied in this approach to benefits estimation, one must exercise caution in drawing inferences from estimates generated by this type of analysis.

Appendix: Freeman's Assessment of the Aggregate Shares Approach

Many of the serious conceptual problems inherent in the aggregate shares approach to benefits analysis have been stated throughout the text of this report. In order to obtain an independent assessment of this technique, A. Myrick Freeman was asked to comment on its possible merits and faults. His response, and an Agency document to which he refers, are provided below.

July 21, 1981

ON DERIVING SECTORAL BENEFIT ESTIMATES FROM NATIONAL AGGREGATE STUDIES

a report to

Public Interest Economics Foundation

by A. Myrick Freeman III

Department of Economics, Bowdoin College

I.

The question to be addressed in this report concerns the conditions under which it is possible to use an aggregate water pollution control benefit estimate as a basis for deriving the benefits of a specific regulation on a specific category of dischargers. The context for discussing the question is the problem of estimating the benefits of BAT effluent standards for the iron and steel industry. The American Iron and Steel Institute has calculated the benefits of this proposed regulation by estimating the iron and steel industry's percentage contribution to total pollution loadings and the percentage contribution of the regulations to total control, and assuming that this represented the proportion of my estimated $12.3 billion national benefits that could be attributed to the regulations. In this report I evaluate the procedures used by the AISI and in more general terms consider the conditions under which that type of imputation might be made.

I first lay out a simple model and use it to establish the conditions under which proportional allocation of aggregate

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benefits to specific regulations is valid. I then consider whether these conditions are likely to be satisfied in practice with the aggregate benefit estimates currently available.

II.

Assume that there is only one polluting substance discharged into the nation's waterways. Let D represent the quantity of this substance which is discharged per year. Suppose that water quality can be measured by a single parameter, Q. Suppose that there is only one activity affected by water pollution. Let X represent the level of that activity per year. Finally let B represent the annual money value of X. It might be helpful to think of the following concrete example: D is biochemical oxygen demand (BOD); Q is dissolved oxygen (D.O.); X is recreation days per year.

The model can be expressed as:

(1) $Q = Q(D)$, $(dQ/dD<0)$

(2) $X = X(Q)$, $(dX/dQ<0)$

(3) $B = B(X)$, $(dB/dX<0)$

By substitution we have:

(4) $B = f(D)$, $(dB/dD<0)$

The benefits of a pollution control regulation that reduces D from D_1 to D_2 $(=\Delta D)$ are:

(5) $\Delta B = f(D_2) - f(D_1)$

Suppose we have estimated ΔB for a major pollution control policy affecting all industries and resulting in $\Delta\bar{D}$. Aggregate national benefits from (5) are $\Delta\bar{B}$. We now wish to evaluate an additional regulation on industry i that will result in a further decrease in dishcarges equal to ΔD_i. Let the benefit be ΔB_i. (An alternative question is how to determine the share of $\Delta\bar{B}$ that can be attributed to the national policy's impact on industry i - as represented by ΔD_i.) Under what conditions can ΔB_i be computed as:

$$\Delta B_i = \frac{\Delta D_i}{\Delta \bar{D}} \Delta \bar{B} \quad ?$$

This requires that dB/dD be a constant. A sufficient condition is that the underlying model of equations (1) - (3) be linear. (Conceivably offsetting non-linearities in (1) - (3) could still leave (4) linear.)

As this simple model makes clear, the basic question posed in the introduction has two components: the adequacy of the single pollutant, single activity model as a representation of the water pollution problem; and the reasonableness of the linearity assumption.

III.

There are hundreds of substances discharged into the nation's rivers. And, what is more important, there are several major categories of activities and uses of our rivers which are affected by changes in various measures of water quality. For example, in my study I identified the following categories of activities or uses for which benefits could be estimated:

Recreation

- Fresh water fishing
- Sports fishing
- Boating
- Swimming
- Water fowl hunting

Nonuser benefits

Diversion uses

- Drinking water - health
- Municipal treatment
- Households
- Industrial supplies

Commercial Fisheries

Let there be n different categories of activities or uses of water bodies represented by X $(i = 1, \ldots, n)$. The total value of all activities is:

$$B = \sum_{i=1}^{n} B_i\,(X_i)$$

To the extent that elements in X are affected by different parameters of water quality and discharges of different substances, then each such category must be analyzed separately in arriving at estimates of national benefits. And imputations to specific industry regulations must also be disaggregated by pollutant and affected category. For example, the category Drinking Water - Health is a function of bacterial and viral contamination of water, while fishing is influenced, at least primarily, by D.O. and BOD.

Several categories of uses are actually affected in complex ways by several different parameters of water quality. For example, fishing depends in part on D.O., but also on temperature and on turbidity. Turbidity itself can be influenced by discharges of several categories of substances, for example, nutrients and suspended solids (TSS). Most of the studies that have been used to generate national benefit estimates have been based on the assumption that there is only one water quality parameter which influences each X_i. The justification for this simplifying assumption is that policy will affect all of the relevant parameters proportionately and that, therefore, one parameter can be taken as a proxy or index of all of the relevant parameters.

Suppose that $X_i = f(D_1, D_2)$ where $f(\cdot)$ reflects both the impact of the D's on the Q's and of the Q's on X_i. To focus on one problem at a time let $f(\cdot)$ be linear. Assume a policy which results in equal proportionate reductions in D_1 and D_2, and that D_1 is taken as a proxy or index for the effect of the policy on pollutant discharges. The change in X_i (and ultimately in B) as a function of the change in D_1 is

$$\Delta X = a\Delta D_1$$

where a is the sum of the partial derivatives $\partial X_i/\partial D_1$ and $\partial X_i/\partial D_2$. (This assumes that the units for measuring D_1 and D_2 are appropriately chosen.) If the coefficient a is then used to predict the effect of a subsequent policy that changes only D_1, then benefits will be overstated, since $a > \partial X_i/\partial D_1$. Similarily, the coefficient a cannot be used to estimate the benefits of a change in D_2, other things equal.

IV.

Suppose that the relevant X_i's and the associated D_i's have been choosen. Benefits for each category can be choosen by using the relevant system of equations analogous to (1) - (3). Is it plausible to assume that these systems are linear, as is required if simple imputations are to be made? It is easy to think of reasons why the system would be non-linear. Dissolved oxygen curves and other relationships involved in water quality modeling are often non-linear. Henry Peskin has said that there are significant non-linearities in the RFF Water Quality Network Model (personal communication). The effects of water quality on activities may involve threshold effects or synergistic relationships and other non-linearities. And economic theory suggests that unit values for activities or uses will typically be functions of quantities, not constants.

Nevertheless, most of the studies I reviewed in my report to CEQ assumed linearity for the purpose of computing national benefits or damages. Given the present state of the art and available data, it appears to be necessary to assume linearity, that is, if estimates of national benefits are to be obtained. Therefore, if a particular estimate is judged to be "reasonable," it is equally reasonable to use that study as a basis for imputing benefits to a particular regulation provided that the imputation is based on the same logic and model structure as the original benefit estimate.

V.

Now let me turn to the AISI report and evaluate their procedure in the context of the preceding discussion. I will make three basic points.

1. One question is whether the imputation follows the same logic as the model underlying the aggregate estimate and whether that basic model is itself reasonable. My report which was the basis of their imputation is a synthesis based on my evaluation of other studies. Thus there is no single model underlying my aggregate benefit estimate. This makes it more difficult to evaluate their imputation. But I will consider the models underlying several of the studies entering into the major components of my synthesis best estimate of national benefits and compare these models with the logic of the AISI imputation.

2. The AISI imputation is based on the aggregate total benefits for all categories. It would have been far better to consider each of the categories separately since the basis for the imputation is likely to vary across categories. For example, their imputation includes a share of the $1.0 billion benefits to Drinking Water - Health. But it is hard to see how the reduction of discharges of substances to be controlled by the BAT standards will contribute to the reduction of bacterial and viral related diseases. But these constitute the whole of Drinking Water - Health benefits.

3. According to the Federal Register notice (January 7, 1981, 1858-1907), the BPT standards for the iron and steel industry controlled primarily TSS, pH, and oil and grease.

The BAT standards being evaluated cover a quite different range of substances. Specifically they control ammonia-N, flouride, phenols, cyanide, benzene, napthalene, benzo-(a) pyrene, trichlorethane, nitro phenol, anthracine, tetrachlorethylene, cadmium, chromium, copper, lead, nickel, and zinc.

We must consider the question of whether the national benefit estimates or any of their major components reflect the benefits of controlling any or all of the substances on this list.

The National Planning Association estimate of fresh water fishing and boating benefits is based on an estimated relationship between participation and water quality as measured by dissolved oxygen and turbidity. The report utilized unit values per recreation day. I do not have access to the report at present. (See Leonard Gianessi at RFF.) I do not remember whether the regression equations were linear. If they were, the model is linear in the relationship between water quality and benefits. But the major quality variable, D.O., is not affected by discharges of substances on the BAT list.

The Battelle estimate of swimming benefits is based on a prediction of the number of miles of public beaches closed due to bacterial contamination. Since the driving factor in this model is a dichotomous variable, the model is non-linear in discharges. Also, bacterial contamination is not affected by the substances on the BAT list. Bell and Canterbery's estimate of marine recreation fishing benefits was based on a complex bio-economic model. I do not have the report. (See Gianessi at RFF.) But it is at least possible that the model is non-linear

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in its biological and economic relationships. Their estimate of marine recreation fishing benefits is quite large, the largest single component in my overall recreation estimate. Others (e.g., Cliff Russell) have suggested that this figure is implausibly high. Since their benefit refers to water quality improvement in a geographically specific area, one should also determine whether discharges from the iron and steel industry have any significant impact on water quality in the marine estuaries. If not, then their use of this component of total benefits for imputation is not justified. The Heintz, Herschaft and Horak estimate of recreaction benefits is based on changes in the number of stream miles polluted. The model is not linear in discharges. I do not know what water quality parameters were used in the determination of whether a stream mile was polluted or not. (I do not have the reference, but it is CEQ, Third Annual Report, 1972, pg. 12, table 7.) I suspect that D.O. was a major variable. This quality measure is not affected by discharges of the substances on the BAT list.

Similarily, Unger's estimate of recreation benefits is based on number of steam miles polluted. Hence, his model is also non-linear in discharges. BOD discharge is used to determine whether a stream mile is polluted. BOD is not on the BAT list.

In summary, it does not appear that the studies underlying the recreation benefit estimate satisfy the conditions for utilizing their proportional imputation technique used in the AISI report. Since my Non-User Benefits estimate is derived as a fraction of the recreation benefits, the same comment applies here. And I have already commented on the problem of using the Drinking Water - Health estimate in this way.

In conclusion, several of the models underlying my national benefit estimate contain non-linearities. Thus a proportional imputation could involve significant error. Also, since most of the benefit categories reflect the control of substances not on the BAT list, their imputation is not valid -- unless it can be shown that the control of BOD, D.O., etc. is a proxy or index for control of substances on the BAT list.

VI.

According to the Rice-Stuart memo of April 22, 1981, the AISI benefit imputation is based on a weighted average of the steel industry's shares of BOD, COD, and TSS discharges in 1968. According to their Table 2, the industry's shares of these three categories of discharges are quite different. Almost 85% of the total discharge by weight is in the form of COD. Only 2% is in BOD. None of the studies discussed above and on which my national benefit estimate was based used COD as a measure of D or a proxy for Q. Therefore, unless changes COD and TSS are correlated with the measures used in these other studies (primarily BOD and bacterial contamination in the cases of recreation and health), the imputation technique is not valid.

I agree with the points made in the agency memo "A Response to the Iron and Steel Industry's Proposed Approach to Benefits Assessment" dated May 6, 1981.

A Response to the Iron and Steel Industry's Proposed Approach to Benefits Assessment

May 6, 1981

At the April 23 meeting concerning the proposed Effluent Limitation Guidelines for Iron and Steel manufacturers, industry representatives suggested a benefit assessment methodology based upon existing estimates of the aggregate benefits of water pollution control. Specifically, the approach relied on Myrick Freeman's 1979 study for the Council on Environmental Quality, entitled The Benefits of Air and Water Pollution Control; A Review and Synthesis of Recent Estimates. In the industry's discussion paper, 6.5% of Freeman's "most likely" estimate of aggregate benefits of $12.3 billion per year (in 1978 dollars) was attached to the proposed reductions in effluent from Iron and Steel plants. 98% of the resultant estimate of $800 million in total annual benefits was then attributed to BPT, and BAT received the remaining 2%.

As was noted at the April 23 meeting, there are a number of serious conceptual problems with the suggested approach of attributing shares of estimates of the aggregate benefits of water pollution control to specific regulatory requirements. First, the aggregate benefit estimates are not regarded with much confidence. For example, the estimates exclude the benefits to be derived from the control of toxic substances, a major consideration with regard to effluent from Iron and Steel plants. Also, the aggregate benefit studies have been derived from extremely limited, and often outdated, data bases that have focused on recreation benefits in a very small number of specific sites. For these reasons, the Agency historically has avoided using estimates of the aggregate benefits of pollution control to justify its regulatory activities.

The second general flaw with the "shares of aggregate benefits" approach involves determining the proportion of benefits that should be assigned to reductions in effluent from Iron and Steel plants due to the proposed BPT and BAT requirements. First, one has to calculate the industry's share of total loadings. For example, the 6.5% estimate used in the industry's discussion paper is a weighted average of BOD, COD, and TSS loadings. Toxics are omitted. Further, the 98% and 2% breakdown derived for BPT and BAT is based on raw waste discharges. The appropriate base case would be 1972 discharge levels (the base year for the benefit estimates). This adjustment would attribute a far greater share of the effluent reduction benefits to BAT.

Even if appropriate shares of discharges could be derived for the industry, and then for BPT and BAT, it would remain inappropriate to equate a percentage change in loadings with an equal percentage reduction in damages (and, hence, an increase in benefits). There is no scientific basis for the assumption, implicit in the industry proposal, that damages (benefits) are strictly proportional to loadings.

In sum, there is little confidence in the accuracy of existing estimates of the aggregate benefits of water pollution control. Further, the potential for error is compounded when shares (percentages) of the aggregate benefit estimates are allocated to pollution abatement efforts across classes of dischargers (e.g., Iron and Steel manufacturers) and across classes of treatment (i.e., BPT and BAT). While such a benefit analysis might generate some useful information, it would be inappropriate to use this approach as the basis for Agency decisions.

AN ECONOMIC ASSESSMENT OF THE BENEFITS OF THE FINAL EFFLUENT LIMITATION GUIDELINES FOR IRON AND STEEL MANUFACTURERS

Volume III: The Benefits of Water Quality Improvements in Three Case Study Stream Segments

May 1982

Benefits Staff
Office of Policy Analysis
U.S. Environmental Protection Agency

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Summary

In order to focus an assessment of the regulatory impacts of its final iron and steel effluent guidelines, EPA chose to undertake three case studies of the incremental costs and benefits of the regulations for three specified stream segments. The results of these studies are useful, both as representative findings of net benefits for geographic regions in which iron and steel facilities are highly concentrated as well as reference findings against which the results generated by the aggregate shares approach to benefit estimation may be evaluated.

The stream segments chosen by EPA are:

1. The Mahoning River between Warren, Ohio and New Castle, Pennsylvania, representing 44.5 river miles and 839 surface acres.
2. The Black River, between Elyria, and Lorain, Ohio, representing 16 river miles and 318.6 surface acres, and:
3. The Monongahela River between Maxwell and Pittsburgh, Pennsylvania, representing 45 river miles and 3640 surface acres.

In pursuing the benefit estimates for these stream segments a variety of analytic techniques were employed including recreation participation models, recreational planning standards and willingness to pay survey data.

A. Benefit Categories

In conducting the case studies EPA selected the same benefit categories as those described in Volume I and assessed in the Volume II aggregate shares analysis and critique. These categories are:

A. Recreation
B. Non-user
C. Health
D. Diversionary Uses

The specific recreation activities examined for the three case streams were fishing and boating. Swimming was not calculated explicitly although swimming values are included implicitly in one measure of benefits.[1] The fishing benefits are primarily attributable on the three streams to a shift from rough to gamefish species. Boating benefits were estimated for all of the case study streams using a variety of analytic techniques.

Nonuser benefits, namely aesthetic, existence and option values, which both residents and non-residents attribute to increments in water quality, were also assessed for each of the stream segments. These measures primarily relate to the values which individuals place upon one's option to enjoy or consume the water resource at some future time, including preserving such use options for future generations; the value society places on the mere existence of an ecosystem resource, and the aesthetic utility which is attendant upon non specific uses of the resource such as transportation, hiking and picnicking.

The health effects of water quality degradation are primarily related to the presence of intakes for municipal drinking water systems and to levels of dermal exposure, due primarily to swimming. The number of intakes on the stream segments studied were fairly limited, and the level of swimming activity presently engaged in, fairly modest. Therefore, health effects did not appear to be significant in the three case stream areas. For this reason, and because of the difficulties of obtaining data on health effects, health benefits were not measured in these case studies.

Diversionary benefits represent the productivity gains realized by stream water diverters as a result of water quality improvements. Although there are a substantial number of water diverters along the case streams, principally the steel companies themselves, none of those surveyed by EPA reported that water quality was a significant factor in the use to which the diverted water was allocated. Municipal drinking water facilities, just downsteam and outside of the Mahoning stream segment, and on the Monongahela river itself may reduce costs as a result of the regulation. These cost have not been explored in detail; therefore no diversionary benefits estimates are included in the total estimate.[2]

B. Methodology

A variety of analytic techniques drawing upon a diverse array of previously developed models were employed in generating incremental BAT-related benefit estimates for the case study streams.

Fishing benefits were obtained by estimating the changes in fishing participation by type of fishing (cold or warm water sport and rough.) The participation model selected is very recent in origin, explaining participation levels by socioeconomic characteristics such as age, income and sex; the local supply of fishable water; the relative supply of fishable waters by type of fish caught and average fish catch for different types of fish. Data on fish population were used to infer the impacts of iron and steel effluent on the supply of fishable water by type of fishing. The results of the model were used to infer changes in activity days associated with various types of fishing, and benefit estimates were generated by valuing these activity days. The value for fishing days are presented by type of fishing and, hence, fishing benefits are presented in like fashion. An estimate of fishing benefits was also made on the basis of recreation planning standards.

Two approaches were used to estimate boating benefits. In the first, recreation planning standards, which provide information that indicates the average observed recreation use levels of water bodies, were specified for each region in terms of activity days. These estimates of the average participation by household, as expressed in activity days per year, were then used to derive a rough measure of the potential increase in recreation by activity for each stream segment. This assumed that average use levels on other water bodies would approximate the incremental activity days attributable to the BAT regulation on the three affected rivers. The incremental activity days were then valued, to derive a range of monetized boating benefits.

A second approach estimated boating benefits based on participation impacts. Using percentage increases in boatable water in each basin attributable to the assumed impacts of the BAT regulation on the quality of the case streams, changes in per household participation rates were derived based on a previously developed participation model of boating. Activity days increases were then estimated and valued.

Nonuser benefits were obtained by drawing upon a survey where respondents (from the Boston area) were asked to estimate their willingness to pay to make all American rivers swimmable. The results of this survey question, with the relevant socioeconomic adjustments, provide nonresident values for the case stream areas. For resident nonuser estimates previous literature on water quality benefits was utilized to obtain a share allocation of nonuser from user (specifically fishing) benefits. The resident and nonresident values were then summed to reflect total nonuser benefits for each of the case streams.

An alternative approach to estimating total benefits (user and nonuser) was demonstrated by a use of the willingness to pay survey model for water-related recreation. Adjustments were made for socio-economic variations between the site of the original study and the case study areas; per household bids (willingness to pay) were derived and total incremental benefits were estimated.

C. Case Study Results

The empirical estimates obtained for BAT benefits on the case study streams are noteworthy for their conformance with previous benefit assessments of water pollution controls and their consistency across methodological approaches. The BAT regulations appear to result in significant economic benefits for each of the case streams studied. All were shown to support higher levels of fishing and boating as well as substantial levels of nonuser benefits due to BAT implementation. The variation in benefits realized across stream segments is related to some or all of the following factors depending on the methodology used: stream length and surface acreage, population level and socioeconomic characteristics, the supply of existing recreation resources and the preregulation level of use of these resources. The results of the case studies are presented in Tables III-1 and III-2. Table III-1 shows the range of annualized benefits for each benefit category, for each case stream and for each methodology used. Table III-2 presents the discounted present value of the upper, lower and best judgement upper bound estimates for each river segment.

Table III-1

Recreation Benefits

(Millions of 1981 Dollars per Year)

River	Estimation Technique		
	Participation Models	Planning Standards	Willing to Pay Survey[a]
Black			
1. Fishing	2.35-2.83	1.68-2.36	---
2. Boating	0.56-1.16	0.25-0.52	---
Total	2.91-3.99	1.93-2.88	2.44-4.83[b]
Mahoning			
1. Fishing	0.25-0.39	2.15-2.73	---
2. Boating	1.30-2.70	1.29-2.68	---
Total	1.55-3.09	3.44-5.41	5.81-8.08[b]
Monongahela			
1. Fishing	5.60 -6.72	10.05-12.75	---
2. Boating	4.53 -9.42	1.94- 4.04	---
Total	10.13-16.14	11.99-16.79	12.30-20.24[b]

[a] The willingness to pay survey includes benefits of attaining swimmable water quality, as well as the benefits of obtaining fishable and boatable waters.

[b] The willingness to pay figures presented in this table have been adjusted so as to delete non-user benefits. Half of the average fishing benefit estimates have been used to make this adjustment.

Nonuser Benefits

(Millions of 1981 Dollars per Year)

River	Estimation Technique			
	Recreation Proportional Survey - Participation		Acreage Proportional	
	lower bound	upper bound	lower bound	upper bound
Black	$ 0.91	$ 1.49	$ 0.24	$ 4.08
Mahoning	0.91	2.15	0.70	12.00
Monongahela	17.99	21.57	3.08	52.69

Table III-2

Present Value of Benefits at Alternative Discount Rates

(Millions of 1981 Dollars Per Year)

	Lower Bound[a]			Best Judgement[b] Upper Bound			Actual Upper Bound		
River	3%	6%	10%	3%	6%	10%	3%	6%	10%
Black River	72.4	36.2	21.7	241.3	120.6	72.4	297.0	148.5	89.1
Mahoning River	75.0	37.5	22.5	404.0	202.0	121.2	669.3	334.7	200.8
Monongahela River	440.3	220.2	132.1	1012.0	506.0	303.6	2431.0	1215.5	729.3

[a] The lower bound estimates were derived by summing the lowest recreation benefit estimate and the lowest nonuser benefit estimate for each river. The actual upper bound estimates were derived in similar fashion, summing the greatest recreation and nonuser values.

[b] Best judgement upper bound estimates were derived by constraining nonuser benefits to be no greater than half of the upper bound estimate for recreation benefits and then adding this figure to the upper bound recreation estimate.

Turning to the rivers themselves, the Monongahela yields the highest benefits. This is primarily a result of its breadth and proximity to population centers. Nonuser benefits are particularly large for the Monongahela in relation to the other streams due in large part to the size of the Pittsburgh population.

The Mahoning River benefits are divided fairly evenly between fishing and boating. No power boating is feasible due to inadequate width and large segments are excluded from any boating uses due to access limitations and dams. No significant potential for swimming is found on the Mahoning.

The Black River, like the Mahoning, exhibits a low potential for increases in swimming activity. Boating benefits are also relatively modest due to the short river segment which is fully navigable. The potential for a cold water sports fishing exists on the Black River however. Fishing, therefore, represents the major area for expansion.

It is beyond the scope of this effort to conclusively infer a national estimate of incremental benefits of BAT iron and steel effluent guidelines. From these case study results we can, however, conclude that significant benefits would result from the regulation. Recreation activity is would be expanded, and welfare gains to nonusers both within and outside of the affected regions also would be realized. Health risks, although not assessed herein, probably are reduced by the regulation, albeit modestly. Indirect food chain effects owing to contamination of fish, as well as direct health effects of dermal exposure are expected to be reduced.

As noted, however, the above benefit estimates are based on "off the shelf" methodologies, drawing upon previously and separately developed estimating techniques. Due to the inherent difficulties of precisely linking such techniques, any emphasis on point estimates should be interpreted with great caution. The causal relationships are not defined with great certainty, the data bases are far from optimal and the transferability of some results is uncertain.

As a result of this set of concerns, we focused upon the specification of broad ranges, reflecting relatively extreme assumptions in both directions. The range of discount rates expanded these ranges. While prudence precludes reliance on any point estimate within the bounds, the breadth of the ranges does suggest that regulations with compliance costs less than the lower bound benefit estimates can be efficient with a very high degree of certainty. This is true for four reasons:

1) Extreme assumptions defining the lower bounds;
2) The failure to explore and evaluate spillover effects outside the basic river basins, e.g., iron and steel effluent degradation of waters downstream of the case study boundaries;
3) The failure to identify and evaluate less certain, yet potential health effects of iron and steel industry discharges, and selected species destruction.
4) The failure to quantify potential future benefits to diverters and commercial fisheries.

Hence, although numerous data and functional uncertainties render any individual result suspect, the consistency of the results overall across methodologies in tandem with the omission of potentially significant benefit categories yield an effective lower bound.

D. Insights Regarding Future Research

The integration of previously developed estimation techniques to obtain the above benefit estimates provides the basic foundation for a generalized efficiency assessment of the iron and steel effluent guidelines. The consistency in the results buttresses the reliability of the estimates, allowing for high confidence that the true result falls within the reported bounds.

Despite this satisfactory result, the exercise did reveal a number of areas where further work is sorely needed in order to advance regulatory impact assessment practices in the water quality management field.

In order to reach beyond the projection of recreation activity based on fish counts, surface acres and the like, we suggest the development of observed data bases relating water quality to recreation activity. As numerous sites such as Lake Michigan, Lake Erie, and the Potomac River recover from severe pollution episodes of the recent past, an expost evaluation of the impacts on recreation activity is both straightforward technically and extremely valuable for future benefit assessments.

The willingness to pay survey approach holds excellent promise as an analytic vehicle for fully capturing the welfare benefit attributable to water quality enhancement. The very limited work conducted to date should be refined and expanded to reduce bias, explore regional variation and test previous results. Selected case studies of this approach would be the most expedient and informative.

The assessment of hydrologic as well as behavioral impacts of toxic discharges is highly problematic. Extensive work is needed to evaluate both short and long term effects of toxics on water related ecosystems and related changes in human activity on or around them.

Recreation participation models have tended to focus on relatively few measures as indicators of water quality. Dissolved oxygen, temperature and suspended solids tend to dominate the literature. Additional work on participation related or other measures as well as other indices reflecting combinations of diverse pollutants is required to expand the application of the participation modeling approach with confidence.

Additional research is needed on the effects of water quality improvements on industrial and commercial facilities. Specifically, a focus on capital and materials life and alternate water supply costs is required. Such research may fill an imposing void in the area of water diverter benefits in future benefit assessments.

Footnotes

1. In principle, our estimates based on total willingness to pay survey results (Chapter 6) should reflect the total benefits of achieving swimmable and fishable (but not necessarily drinkable) river water quality. These estimates should therefore be greater than the sum total of our estimates of fishing, boating, and nonuser benefits. This is generally the case and it is evidence of the consistency of the various methodologies we have used.
2. Some discussion of diversionary benefits is presented in an appendix.

1. Introduction

As noted in Volume I, there are formidable constraints to conducting an analysis of the economic benefits attributable to the final iron and steel industry effluent guidelines. In addition to uncertainties regarding causal relationships, both physical and behavioral, and the absence of key data, there exists the dilemna of allocating primarily regional direct benefits to a disparate national population. In order to focus the research effort, the decision was made to analyze intensively the effects of the regulation on three case streams: the Black River in northern Ohio, the Mahoning basin in eastern Ohio and southwestern Pennsylvania, and the Monongehela River in central Pennsylvania.

The examination of this subset of affected stream bodies provided the basis for a limited, yet hopefully representative assessment of the benefit-cost relationship which obtains for the regulation on a national basis. Areas and populations directly affected are focused upon, thus reducing behavioral uncertainties.

One must be highly cautious, nonetheless, in interpreting the case study results. No one result nor the combined results are fully suggestive of the relative merit of the regulation.

The case streams represent a combined mileage of 105.5 and surface acreage of 4,797.6. They drain 8 counties with a total population of 3,133,257. The stream segments are adjacent to 11 operating steel facilities.

In conducting the case studies, the Public Interest Economics Center (PIE-C) examined in detail two of the four general categories of benefits noted in Volume I.

These are:

1. Recreation, specifically fishing, and boating;
2. Nonuser benefits;

Each of these categories are addressed in turn below for each of the stream segments studied. The theoretical foundations of each of the benefit forms is presented, the functional relationships which ultimately lead to a monetized benefit estimate are specified, the methodology(s) described and empirical results presented. Ranges for each category on each stream are derived based upon alternative assumptions and techniques, and a sensitivity analysis, based on varying discount rates is also presented (in the summary).

The recreation and nonuser categories represent a very large share of expected benefits and only these are calculated. Health effects were not empirically estimated due to absence of adequate dose response data. This does not infer the absence of adverse health impacts of iron and steel effluent, only our inability to adequately specify the bounds of these effects with the information available. However, pollution related health effects are not expected to be substantial along the case study rivers due to the advanced treatment present at the affected public water supplies. Diversionary uses are briefly discussed; yet, since only two facilities on the Monongahela River exhibited any potential costs savings in relation to the BAT regulation, potential benefits accruing to diverters were not included in total benefit computations.

The work undertaken in this report uses as its starting point descriptive and analytical material presented in the "Preliminary Assessment of Projected Water Quality Benefits from Implementation of the Proposed Regulations Defining Best Available Technology Economically Achievable for the Iron and Steel Industry," prepared by EPA's Office of Water Regulations and Standards. Initially, in Chapter 2, descriptions of the three case streams are presented. These provide the background for evaluating the plausibility of the benefit estimates derived from the various models. Subsequently, participation models for fishing and boating are described, and evaluations made of the estimates produced by these models for the three case streams. The fifth chapter describes an alternative approach, i.e., planning standards, to calculating fishing and boating benefits. Chapter 6 describes an alternative approach to calculating recreation and nonuser benefits. In that chapter the willingness to pay survey method is used to calculate the benefits from the regulation. Nonuser benefits are calculated in Chapter 7 using an estimated relationship with recreation based on the results of several previous studies as well as alternative method using total acreage. Finally, a short description and a discussion of potential diversionary use benefits are presented in an appendix.

2. Physical, Social and Economic Characteristics of the Three Case Rivers and Surrounding Regions

2.1 The Monongahela River[1]

a. Stream Description

The Monongahela River is formed by the confluence of the West Fork and Tygart Rivers near Fairmont, West Virginia. The river flows for 128 miles north, where it joins the Allegheny River in Pittsburgh to form the Ohio River. The Monongahela drains an area of 7,386 square miles in southwest Pennsylvania, northern West Virginia and northwest Maryland. Most of its length is characterized by steep banks and rugged terrain as it passes through the Appalachian Plateau and Allegheny Mountains.

This study concentrates on river mile (RM) 45 to RM 0, the latter point being where the Monongahela joins the Allegheny at Pittsburgh. Downstream of RM 45 in our segment of interest the width ranges from 600 to 800 feet and is more than 9 feet in depth. The deeper portions of the river are at impoundments formed by a series of locks and dams. Three such locks and dams are found in this portion of the river. The river banks are lined with small towns, factories and railway lines.

b. Water Quality and Uses

The major point source dischargers on the river segment of interest are five iron and steel facilities and a power generating plant. The main stem of the Monongahela is affected by various kinds of industrial and urban discharge, by municipal sewage discharge, by thermal discharges from power generating plants, by acid mine drainage from abandoned mines, and by urban runoff and industrial waste.

Most sources of industrial and municipal water pollution are concentrated in the lower 40 miles. These municipal and industrial wastes cause excessive bacterial densities, deplete dissolved oxygen, and form toxic oil sludges.

Most of the recognized water quality problems on the Monongahela are inversely related to flow. The pertinent flow related parameters are: temperature, dissolved oxygen, pH, total dissolved solids, suspended solids, turbidity, color, hardness, metals and nutrients. A privately owned power plant, Lake Lynn, located at the West Virginia-Pennsylvania border, produces up to 19 megawatts of power and discharges into the river. Because of discharges from Lake Lynn, hourly flow rates tend to fluctuate widely below river mile 90. Variations in several water quality parameters can be seen in Table III-3

The chemical quality of surface water has also varied widely. Until recently, for example, the river's mainstem had been acidic throughout its length. There have also been recurring incidents of taste and odor problems in water supplies taken from the Monongahela, necessitating expensive treatment systems.

Throughout the 1970's monitoring stations recorded severely degraded water quality conditions on the river. For example, during a 1972-73 monitoring, seven stations in the basin violated the criteria for pH in more than 20% of the samples.

The most notable water quality problems throughout this period have been associated with discharges of phenol, cyanide, ammonia and BOD with frequent violations of the Pennsylvania standards for the former two pollutants. Phenol readings in the range of 25 to 35 ug/l were reported as late as July 1981. (The Pennsylvania water quality standard for phenol is 5 micrograms per liter (ug/l).

Table III-3

Selected Parameter Readings Taken At Low Flow

(7/28/75 to 8/1/75)

	River Mile	Flow (CFS)	Temperature (c°)	Dissolved Oxygen (mg/l)	Surface PH	Transparency (Secchi disk-ft.)
				>7.0		2
Allegheny	0		28-30			
				5.0-7.0*		4
	10					
L&D Number 2			26			
Youghiogheny				<5.0		2
	20		30-32		7.0-7.5	
L&D Number 3			30-34			4
	30					6
	40			>7.0		
L&D Number 4		900-3,000	26-28			4
	50					
			28-30		6.0	8
	60					10
Maxwell L&D			26-28	6.0-7.0		
					5.0	
	70				4.0	6
	80			>7.0		
L&D Number 7		500-4,000	24-26			
			24			2
Cheat River	90				5.0	
L&D Number 8			26-28	6.0-7.0		
						4
	100					2
Morgantown L&D				>7.0		
Hidelbrand L&D			24-28*		7.0-7.5	5
	110					3
Opekiska L&P		800-900		>7.0*		
						3
	120			>7.0- <5.0*		3
						5
	128					

*Denotes significant stratification.

†Peak flows correspond to Lock & Dam Number 7.

Source: U.S. Army Corp of Engineers.

Iron and steel plant loadings of phenol, cyanide and ammonia are estimated and presented in Table III-4. This table contrasts current loadings with permit limits, BPT limits and BAT limits. Notice that current discharges for the most part comply with permit and BPT levels, but not with BAT levels.

As to the consequences of reduction in effluent loadings and treatment of discharges, some improvement in water quality has occurred in the lower portion of the Monongahela. Since 1970, many active mine discharges within Pennsylvania have been treated. However, not all active mines with discharges in West Virginia are in compliance with that state's standards.

Recreational use of the Monongahela has increased considerably over the last 10 years. Public and private facilities which have been developed include single lane boat launching ramps, boat club docks, commercial marina and community parks. The primary recreational activity on the river are power boating, water skiing, and fishing. Swimming is reported to occur in several spots. Table III-5 shows the estimated number of participation days in various recreation activities in several portions of the river in 1980.

While most fishing is by boat, considerable fishing from shores occurs even in heavy industrial areas. Access is available along roads and railways with little posted property. Some municipalities are building municipal fishing piers in an effort to improve access.

The railroad company uses the water from the river for steam heat generation and does pretreat. However, pretreatment is independent of the water quality since the pollutants in the river do not have any impact on their operation.

Table III-4

Monongahela River - Iron and Steel Loadings in lbs/day

Plant	Current			Permit			BPT			BAT		
	Phenol	CN (Free)	NH_3	Phenol	CN (Total)	NH_3	Phenol	CN (Total)	NH_3	Phenol	CN (Total)	NH_3
1. Wheeling - Pittsburgh Monessen Plant (RM 39.3 - 40.4)	100	22 (Free)	1096	22	1.5	879	11.4	64.4	664	1.35	7.0	33
2. USSC - Clairton (RM 19.3 - 19.8)	3.5	47 (Free)	2038	24	24	6657	14.6	183	3656	1.1	54	325
3. USSC - National Duquesne (RM 10.8 - 11.4)	1.0	4.0 (Free)	114	4.4	2.2	2068	33	155.4	1064	0.3	5.2	5.5
4. USSC - Edgar Thompson (RM 10.8 - 11.4)	3.0	13 (Total)	172	31	31	1588	25	117	804	0.2	4.4	4.4
5. USSC - Homestead (RM 6.9 - 9.2)	6.0	6.0 (Free)	215	27	22	1524	30.8	148.8	963	0.8	7.6	4.7
6. J&L - Pittsburgh (RM 2.4 - 4.5)	276	112 (Total)	20851	8.8	2.2	2010	26.4	166	2024	0.6	24	128

Source: "Preliminary Assessment of Projected Water Quality Benefits from Implementation of the Proposed Regulations Defining BAT Economically Achievable for the Iron and Steel Industry," OWRS, USEPA, Wash. D.C.: August 7, 1981 (Draft).

Table III-5

Recreation Characteristics of the Lower Monongahela River

	Number of Annual Recreation Days 1980		
Activity	RM 10/L&D*2	RM 23/L&D3	RM 40-45 L&D 4
Picnicking	0	510	425
Swimming	1,680	2,550	2,310
Waterskiing	2,520	3,825	3,195
Boating	11,760	16,575	13,845
Sightseeing	168	510	63
Fishing	1,680	2,550	3,195
TOTAL RECREATION† DAYS	17,808	26,520	23,430

*L&D = Locks and Dams

†Recreation Day is defined as a significant portion of a day in which recreationists participate in one or more outdoor activities.

Source: U.S. Army Corps of Engineers

The Western Pennsylvania Water Company in Allegheny County uses the Monongahela as a source of raw water. Two of their water intakes are situated along the lower 45 miles of the Monongahela. One is located at Beeks Run (RM 4.5), the other at Elrama (RM 25.3). Water from these intakes is delivered to a combined population of 126,000. The degraded quality of the water has necessitated extensive treatment before use at the tap.* In addition, Baltimore and Ohio Railroad Company (Chessie System) at RM 5.1, Pennsylvania Industrial Chemical Corporation (Hercules) at RM 23.8,

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*For more information on the type and extent of treatment, see EPA's Office of Water Regulations and Standards "Preliminary Water Quality Benefit Assessment," August, 1981.

Dusquesne Light Comapny at RM 25.1 and the West Pennsylvania Power Company (Mitchell Plant) at RM 29.5 all intake water from the Monongahela River.

The chemical and power companies intake water for cooling purposes only and do not treat the water before use. The Duquesne Light Company engages in extensive pretreatment. Chlorination treatment is required for contact cooling water to prevent scaling. This service water is first screened, then taken through a series of clarifiers. Treatment costs would be reduced if the water quality were improved but the magnitude of these savings has not been investigated.

c. Biology

Fish surveys conducted in the Monongahela River as late as 1978 revealed a significant reduction in fish species downstream of the pollution dischargers. The segment of the river that is most affected lies between RM 32.2 and RM 42 and is highly correlated with proximity to iron and steel dischargers. Results of the fish survey as well as projected fish population (under BAT guidelines) will be discussed fully in the subsequent chapter.

d. Socioeconomic Characteristics of the Monongahela River Region

Socioeconomic indicators of the counties surrounding the Monongahela river (Allegheny, Westmoreland, Fayette and Washington) are noted below. These local indicators are in most instances compared with national parameters in order to provide an insight into the background and relative standing of the region.

Figures from the 1980 census[2] indicate a population of 2,219,848 for the aforementioned counties combined with the heaviest concentration in the city of Pittsburgh (19.1%), located at the mouth of the river.

In 1978 females accounted for just over 50 percent at both the local and national levels[3] of the population. For that same year, 12.7% of the population was 65 or older. This was 1.7 percentage points above the national average.

Whites represented 91.6% of the area's population in 1980, compared with a national representation of 83%. The representation in Pittsburgh for Whites and Blacks was 74.7% and 24.2%, respectively.

The median years of school completed by those 25 years old and older in 1970 was 12 years.[4] Four or more years of high school were completed by 49.5% of the region's population. Only 7.2% finished four years of college, compared with the national proportion of 10%. This statistic ranged from a low of 4.6% in Fayette County to a high of 11.1% in Allegheny County.

The three major employment categories in 1980 were manufacturing (27.8%), wholesale and retail trade (25.9%), and services (24.8%).[5] Since 1970, employment in manufacturing has decreased 12.6% while services, and the wholesale and retail trade sector have increased by 137.9% and 16.1%, respectively. The primary metal industry (SIC 33) is the largest employer in the region with over 38% of the total manufacturing employment. Its 142 firms employ 66,980 workers and account for 8.8% of the region's privately employed population.

In 1980 there were representatives from virtually all major industrial classification groups. In addition to the primary metal group, the predominant groups (i.e., those with greater than 5% of the region's employees) were eating and drinking places (SIC 58) and health services (SIC 80). Total private sector employment in 1980 was 774,537, which was a 19.4%

increase over 1970. The unemployment rate for the region in 1975 was 7.1% and increased to 7.8% in 1980. The unemployment rates ranged from 6.5% in Allegheny County to 11.9% in Fayette County. The national unemployment rates for 1975 and 1980 were 8.5% and 7.1%, respectively.

Per capita income for the region in 1977 was $5,944 compared with $6,046 for the nation.[6] By county, the per capita income (in 1977 dollars) ranged from a low of $4,338 in Fayette to a high of $6,347 in Allegheny.

2.2 The Mahoning River[7]

a. Stream Description

The Mahoning River flows through the northeast region of Ohio in an easterly direction down through the west central region of Pennsylvania. Two separate branches of the Mahoning converge southwest of Warren, Ohio, in Trumbell County to form the main body of the river. The west branch of the Mahoning originates at the West Branch Reservoir in Portage County and the east branch originates in Lake Mirroir in Mahoning County.

From Warren, the Mahoning flows southeast, back through Mahoning County and Youngstown City, across the Ohio-Pennsylvania border into Lawrence County and there meets the Shenango River just south of Lawrence City. The length of the Mahoning River is 108.3 miles. Its major tributaries are Mosquito Creek, Meander Creek, and Mill Creek. The entire drainage area of the river basin is 1132.8 square miles and the elevation of the stream is 1197 feet at the source and 769 feet at the mouth. The river falls at an average of 4.0 feet per mile.

This study concentrates on the segment of the Mahoning River between the City of Warren and the confluence with the Shenango. Measured from this confluence to Warren, the river spans river mile (RM) 0 to RM 45. This segment varies in width from 89 to 216 feet, and varies in depth from 2 feet to 9 feet. It occupies approximately 839 acres of water area. Summer flow rates vary from 315 cubic feet per second (cfs) at RM 42 to about 571 cfs at RM 8.

b. Water Quality and Users

The water quality of the Mahoning River is affected by heavily polluted discharges from steel manufacturers and sewage treatment plants. Some of these discharges approach raw waste loads. Prior to 1977, there were 9 steel plants, a power generating station and eight sewage treatment plants. But between 1977 and 1980, five of the oldest steel plants closed. Almost all major discharge points are located in Ohio between river miles 12.81 and 42.57. One sewage treatment plant is located in Pennsylvania near river mile 1.5.

Discharges of phenol, cyanide, ammonia, oil and heat result in numerous violations of Ohio's general statewide warm water habitat standards. Discharges of BOD_5 from sewage treatment plants and discharges of heat from the power generating station are partly responsible for a severely depressed dissolved oxygen level.

Current water patterns (low flow augmentation, temperature and flood control) are maintained by a system of reservoirs. Water quality improvements are expected as a result of steel plant closings and increased compliance with municipal and industrial NPDES permits.

The Mahoning River is currently unattractive as a recreation site. Between Warren and downstream of Youngstown, there is little recreational activity due to poor access and the degraded conditions of the river.

Access to the river is difficult due to railway lines, highways, industrial complexes and the river's steep banks. The odor, industrial scenery and numerous dams discourage canoeing and the river's width and depth negate power boating. Near the Ohio-Pennsylvania State line and in Pennsylvania, the river is accessable and quite scenic. Increased recreational use of this area is likely with aesthetic and water quality improvements.

Fishing currently is not popular on the Mahoning River below Warren. However, a diverse warm water fish population would be possible as evidenced by the species and diversity upstream of the polluted section.

There is only one diverter of water on the Mahoning, aside from the steel industry and the purpose for which the water is used requires no treatment prior to use. The Ohio-Edison Niles Electric Steam Generating Plant intakes water for steam generator cooling purposes. Water for other industrial uses by this firm is obtained from the Niles city water supply. However, Beaver Falls, Pennsylvania is served water from the Beaver River which is directly affected by discharges from the Mahoning.

c. Biology

In 1980, species of fish in the Mahoning River ranged from 38 above the first effluent discharge point (RM 42.6), to 6 below the Youngstown Sheet and Tube Company plant (RM 15.9). Below the RM 15.9 the number of sports species observed over the length of the segment exhibited the same pattern. A maximum of 19 species were seen at RM 42.57 with considerably less (3) observed at RM 15.9. Below this point, 5 species were noted. Indications are that the number of species varies inversely with the levels of ammonia, cyanide, phenols and temparature related low levels of DO.

d. Socioeconomic Characteristics of the Mahoning River Region

Socioeconomic data on the counties surrounding the Mahoning River is presented below. In addition, this data is compared with national statistics as a means of establishing the relative placing of the region in the national setting.

The 1980 census figures indicate a population of 638,500 in the three counties surrounding the Mahoning River (Trumbull, Mahoning, Lawrence), with the heaviest concentrations in Youngstown (13.7%) and Warren (6.7%).

The male-female ratio for the region as a whole and for the nation was approximately one to one. In 1977, 10.2% of the combined population of Mahoning and Trumbull Counties were 65 years old and older, while in 1978, 12.3% of the population of Lawrence County were over 65 years old. The proportion of the nation's population in this age group in 1978 was 11.0%.

In 1980, the proportion of Whites in the Mahoning River region was 90.09%, compared with a national representation of 83%. The major ethnic groups, (i.e., those with greater than or equal to 1% of the population) are Blacks (9.2%) and people of Spanish origin (1.1%). Whites in the cities of Youngstown and Warren were 64.4% and 81.1% of the population, respectively.

The median number of school years completed by those 25 years and older in 1970 was 12.0 years compared with the national average of 12.2 years. Four or more years of high school were completed by 51.8% of the region's population. Only 6.8% had 4 years of college, substantially below the national proportion of 10%.

The three major employment divisions in 1980 were Manufacturing (40.5%), Wholesale and Retail Trade (26.0%) and Services (19.7%). Since 1970, employment in Manufacturing has decreased 17.5% while Services and Retail Trade have increased by 205.3% and 23.6%, respectively.

The Primary Metals industry (SIC 33) is the largest employer in the Mahoning River region. Its 66 firms employ 31,029 workers, or account for 15.7% of the region's privately employed population.

In 1980 the manufacturing firms in the region were representative of virtually all industrial classifications groups. In addition to the Primary Metal group, the predominant groups (i.e., those with greater than 5% of the regions employees) were Health Services (SIC 80), Eating and Drinking Places (SIC 58) and Fabricated Metal Products (SIC 34).

Total private industry employment in 1980 was 197,333. This was a 11.7% increase from 1970. The unemployment rate for the region in 1975 was 11.3% and increased to 11..6% in 1980. The unemployment rates in 1980 ranged from 10.5% in Lawrence County to 12.2% in Trumbull County. The national unemployment rates for 1975 and 1980 were 8.5% and 7.1%, respectively.

Per capita income for the region as a whole in 1977 was $5,676, compared with $6,046 for the nation. The per capita income by county ranged from a low in Lawrence County of $4,787 to a high in Trumbull County of $5,954.

2.3 The Black River[8]

a. Stream Description

The Black River is situated in the North Central region of Ohio and is contained mainly within Lorain County with small segments extending into Huron, Cuyahoga, Medina and Ashland Counties. It originates near the boundary between Sullivan and Troy townships in Ashland County. From the origin, the main body of the water, including the east and west branches, flows 78 miles to Lake Erie at Lorain. The West Branch and French Creek are the main tributaries and form confluences at River Mile (RM) 15.4 and RM 5.1, respectively. The entire drainage area of the River basin is 467 square miles and the elevation of the stream ranges from 1138 feet above sea level at its origin to about 573 feet at the mouth. The elevation of 573 feet, which is also the level of Lake Erie, actually starts at about RM 6.5.

This study is mainly interested in that segment of the river from the confluence of the east and west branches, to the mouth at Lake Erie. Measured from the mouth of the river upstream, this portion spans river mile (RM) 16 to RM 0 and amounts to approximately 320 acres in area. Above RM 6.5, the Black River is a shallow free flowing stream with moderate velocity and slope. Downstream of this point, the backwaters of Lake Erie form an estuary to influence the water level.

An average depth of about 1 foot defines the area between Elyria Sewage Treatment Plant (STP) and RM 6.5. The estuarine portion of the river (RM 0 - RM 3) is dredged to a depth of twenty to thirty feet. The flow at the U.S. Geological Survey gauging station at Elyria exceeds 50 cubic feet per second (cfs) only half the time. Expected mean monthly flow may range from 31 cfs in September and October to about 800 cfs in March.

The general topography and character of the land surface reflects glacial action during the Illolonian and Wisconsin periods. The surface is low and relatively flat with a gentle slope in the southern region extending to the lake shore. Glacial deposits in the river contain only limited amounts of permeable sand and gravel, consequently, ground water storage is very poor. The bedrock in the region is primarily shale and contributes virtually no groundwater to The flow of the river. Further, there are no significant reservoirs or water developments to augment the flow.

b. Water Quality and Uses

The water quality of the lower 10 miles of the river is described as water limiting due to the low water quality design flow coupled with extremely high levels of pollution. The major point source effluent dischargers affecting the water quality are: (1) the U.S. Steel Corporation Lorain Works (USSC) between RM 2.6 and RM 5; (2) Elyria STP at RM 10.4. Downstream from the STP to Lake Erie, water quality is very poor due to heavy discharges from these sources. In 1979, USSC discharges of ammonia, cyanide, dissolved oxygen (DO) and phenol were in violation of the Ohio Water Quality Standards. Discharges from hot forming operations contributed to violations of DO standards as well as violations of temperature and oil standards. Since 1979, the level of discharges has been reduced somewhat, due to recent improvements in waste water treatment.

The most significant municipal discharger is the Elyria STP. A second source, the Lorain STP is located at the mouth of the river at Lake Erie. However, more efficient treatment techniques coupled with the hydrology of the area makes the impact on the water quality of the Lorain STP less significant. Lack of pretreatment of industrial discharges of heavy metals leads to plant upsets at the Elyria STP, resulting in the discharge of high loadings of oxygen demanding matyerials (BOD and ammonia). Further, high concentrations of cyanide, phenol and varying metals were found among the plant's effluent.

The river has potential for supporting various recreational activities. However, current recreational activities on the river are limited to boating and fishing. Fishing is the most popular activity and is attempted along the entire length of the lower 12 miles of the river. Canoeing and pleasure boating are also attempted but are not very popular due to the poor quality of the water. An additional constraint is that only the lower 6.5 miles are navigable by power boats. About half of this portion is of some scenic value to boaters; with the remaining portion of this stretch accommodating the USSC facility. Nevertheless, boaters who presently fish on the lake may be attracted to the navigable portions of the river, RM 0 to RM 6.5. Boating activity could be further enhanced upon the realization of a large marina that is being contemplated for Lake Erie (at the mouth of the Black River).

Several parks and two golf courses (one private and one public) are situated along the river upstream of the Elyria STP. Downstream of this facility, there is one park located at the mouth of the French Creek. The parks support activities such as picnicking, hiking, and hunting. The length of the hiking trails is estimated to lie between 15 and 25 miles. In the past, water skiers were observed in the turning basin at U.S. Steel. The golf courses do not sponsor any water related activites and the river is of scenic value only.

There are reportedly two major diverters of water on the Black River. The American Shipbuilding Company at RM 0.7 intakes water for the purpose of cooling air compressors. The poor water quality is of secondary concern to the production process and therefore the necessity for water treatment does not arise. In addition, about 173 million gallons per day (mgd) of water is withdrawn from the river by the USSC at Lorain. This water is used for cooling, scale removal and gas cleaning, purposes for which no pretreatment is required.

c. Biology

From 1889-1892, as many as 83 species of fish were found in the Black River and adjacent Vermillion River. By 1960, 48 species and 5 hybird combinations of fish were found. In 1977, 24 species were found 2 miles downstream of the steel plant. A maximum of 8 species were reported between USSC and the STP. Just upstream of the STP, 19 species were sampled and as many a 23 were seen further upstream. Other biological life includes ducks which have been observed in the vicinity of the American Shipbuilding Company. Wild geese have also been noticed further upstream at the Elyria STP.

A spokesperson for the Polish Fisherman's club revealed that, historically, recreational activities on the Black River were limited to fishing prior to 1958. There were no public parks or organized recreational activities along the river before 1958.

Similiar tributaries to the lake such as the Rocky and Vermillion Rivers are currently being stocked with desirable species (i.e., Rainbow Trout, Coho Salmon). These species are characteristic of clean cold water, and are currently not found in the Black River.

The French Creek which forms a confluence at RM 5.1 supports extensive fishing, picnicking, hiking and canoeing. These activities are engaged in despite the poor water quality and lack of desired fish species.

d. Socioeconomic Charateristics of Lorain County

In order to provide readers with a picture of the relative socioeconomic position of residents of Lorain County, local and national data are compared below.

Figures from the 1980 census indicate a population of 274,909 for Lorain County with the heaviest concentrations in Elyria and Lorain, two cities located along the Black River. The population of Elyria and Lorain are 57,504 and 75,416, respectively.

In 1977, there were approximately the same number of men and women residing in the county. For that same year, 1 out of every 12 persons in the county was 65 years old and over. This was below the national average for the previous year when the proportion was 1 out of every 10.

Whites represented 90% of the county's population compared with the national representation of 83%. The remaining 10% of the population were comprised of several different ethnic groups with the major ones being Blacks (7%) and people of Spanish origin (3%). White representation was 86% and 79% for the cities of Elyria and Lorain, respectively.

The educational attainment of residents of Lorain County is representative of the surrounding counties but was below the national level. In 1970 the median years of school completed by those 25 years old and over was 12.1. Only 52.6 percent had four or more years of high school. 7.1 % had four years of college, substantially below the national average of 10%.

Industrial activity dominates the economy of Elyria and Lorain, with agricultural activity predominanting throughout the remainder of the area. The three major employment divisions in 1980 were manufacturing

(45.5%), wholesale and retail trade (21.4%), and services (19.1%). Since 1970, employment in manufacturing has decreased 4.1% while services and the wholesale and retail trade sector have increased by 320.0 % and 29.8%, respectively. Within the manufacturing sector, the Transportation Equipment industry (SIC 37) is the largest employer in Lorain County. Its 17 firms employ 11,302 workers or 15.0% of the region's privately employed population. The largest company in the county is the U.S. Steel plant at Lorain where at full production employment is around 8,500. The Ford Motor Company at Lorain is next largest followed by GMC-Fisher Body at Elyria.

Total private industry employment in 1970 was around 59,831. Between 1970 and 1980, the number of people employed had increased by 26.2% to 75,524 and the unemployment rate had risen from 9.5% to around 13.0%, almost doubling the national rate of 7.1%. One possible explanation for the increase in unemployment is that the recent sluggishness of the auto industry, and of the U.S. economy in general, has affected the 10,569 workers of the two auto manufacturers. Employment projections suggest that by the year 2,000, the labor force will amount to 142,240 with approximately 11,009 of this number being unemployed.

Per capita income for the nation in 1977 was $6,046 compared with $5,879 for Lorain county. In terms of household income, the figures are $17,519 and $18,017 for Lorain County and the nation, respectively.

FOOTNOTES

1. Most of the information on the physical characteristics of the Monongahela River was obtained from:

   William Desvosuges and Matthew McGiveney, Research Triangle Institute Interim Report on Measuring the Recreational Benefits of the Monongahela River (Research Triangle Park: Research Triangle Institute, August 10, 1980).

   Additional Information was obtained from:

   U.S., Office of Water Regulations and Standards, Environmental Protection Agency, "Preliminary Assessment of Projected Water Quality Benefits from Implementation of the Proposed Regulations Defining BAT Economically Acheivable for the Iron and Steel Industry" (Washington: Draft, August 7, 1981).

2. Population and race data for the counties surrounding the three rivers were drawn from:

   U.S., Bureau of the Census, 1980 Census of Population and Housing, #'s PHC80-V-37 and PHC80-V-40 (Washington: Department of Commerce, March, 1981).

   National race data were obtained from:

   U.S., Bureau of the Census, 1980 Census of Population and Housing, U.S. Summary, Advance Reports, #PHC80-V-1 (Washington: U.S. Department of Commerce, April, 1981).

3. Female to male ratios and age distribution figures for Pennsylvania were drawn from:

   U.S., Bureau of Census, "Estimates of the Population of Counties by Age and Sex: July 1, 1978, State of Pennsylvania" (Washington: Unpublished Data).

   The same numbers for Ohio were from:

   U.S., Bureau of the Census, "Experimental Estimates, July 1977" (Washington: Unpublished Data).

   National data was obtained from:

   U.S., Bureau of the Census, Estimates of the Population of the U.S. by Age, Race and Sex: 1976-1979, P-25-870 (Washington: U.S. Government Printing Office, January, 1980).

4. Education data for the three river regions was drawn from:

U.S., Bureau of the Census, County and City Data Book, 1970, (Washington: U.S. Government Printing Office, 1977).

National Data was drawn from:

U.S., Bureau of the Census, Demographic, Social and Economic Profile of States: Spring 1976, P-20, #334 (Washington: U.S. Government Printing Office, January, 1979).

5. Employment data for the three river regions was obtained from:

U.S., Bureau of Labor Satistics, "Annual Average Reporting Units and Employment for Private Industry in Selected Counties in 1970 and 1980" (Washington: Unpublished Data).

Unemployment data was obtained from:

U.S., Bureau of Labor Statistics, Employment and Unemployment in States and Local Areas, 1980 (Washington: U.S. Government Printing Office, June, 1981).

U.S., National Technical Information Service, State Counties and Selected Cities Employment and Unemployment, January to December 1975, PB80-914418 (Washington: September, 1980).

National employment and unemployment data was drawn from:

Economic
Printing Office, 1981).

Additional employment data for the Black River region was drawn from:

U.S., Environmental Protection Agency, Black River Waste Load Allocation Report (Region 5: EPA, 1981).

6. Per capita income for the three river regions was obtained from:

U.S., Bureau of the Census, 1977 Per Capita Money Income Estimates For States, Counties, Incorporated Places and Minor Civil Divisions, #882 (Washington: U.S. Government Printing Office, 1977).

National data was obtained from:

Economic Report of the President (Washington: U.S. Government Printing Office, 1981).

7. Information on the Physical Characteristics of the Mahoning River was obtained from:

   Gary Amendola, Donald Schregardus, Daniel Murray and David Barna, Mahoning River Waste Load Allocation Study (Westlake, Ohio: Environmental Protection Agency, November, 1980).

   U.S., Office of Water Regulations and Standards, Environmental Protection Agency, "Preliminary Assessment of Projected Water Quality Benefits from Implementations of the Proposed Regulations Defining BAT Economically Acheivable for the Iron and Steel Industry" (Washington: Draft, August 7, 1981).

   Richard S. Thorn and Jack Ochs, "A Study of the Social and Economic Benefits of the Implementation of the Pennsylvania Water Quality Standards on the Mahoning River" (Pittsburgh: Iron and Steel Institute, Unpublished, May 5, 1977).

8. Most of the information on the physical characteristics of the Black River was obtained from:

   U.S., Environmental Protection Agency, Black River Waste Load Allocation Report (Region 5: EPA, 1981).

3. Fishing Benefits--Participation Approach

3.1 Introduction

In this section, a participation model is used to project increased fishing activity expected to result on the 3 case streams from the implementation of the iron and steel effluent regulations. The plausibility of estimates derived from the model is then discussed in the context of site (river) specific considerations.

The participation "approach" to measuring fishing benefits is discussed briefly, followed by a description and evaluation of the model used and its applicability to measuring fishing benefits for the three case streams.

There are two important relationships to be considered in analyzing the effect of water quality on fishing:

1. the effect of water quality on the availability of fish, by species; and
2. the effect of this availability on fishing participation.

Furthermore, there may be a "perception" effect on fishing activity that is independent of the availability of fish, implying a negative response towards fishing in "polluted" water.

Studies undertaken on fishing participation and its relationship with water quality have tended to focus on objective relationships, such as the biological relationship between water quality parameters and the supply of fish and/or the behaviorial relationships between the supply of fish and participation. Some studies have measured the perceptual relationship indirectly by estimating the relationship between objective water quality parameters and participation (eg., National Planning Association, 1975).

The effects of certain water quality parameters on recreational fishing has been clearly demonstrated in all such research.

Studies documenting the importance of the effect of changes in the supply of fishable water and in the stock of fish on the behavior of recreational fishermen have demonstrated that fishermen are sensitive to increases in fishing opportunity and to changes in fish composition. These studies have also shown that the amount of time spent fishing is an increasing function of acreage available for recreational fishing, and that fishermen prefer trout over bass fishing, and bass over rough fishing. These studies stress the importance of supply variables in the fishing participation equations. (Vaughan and Russell, 1981 forthcoming; NERA 1976)

The relationship between fish species and water quality parameters such as dissolved oxygen (D.O.), temperature, total suspended solids, (TSS), and pH has also been established. Further, water quality parameters such as D.O., temperature and turbidity have been shown to have a positive relationship with participation. While it is known that toxic metals, oil and grease, ammonia and other pollutants discharged by the iron and steel industry have negative impacts on aquatic species, there is little economic information available that incorporates the relationship between individual pollutants generated by the iron and steel industry and participation.

The fishing participation model used in this study to measure the benefits from a reduction in effluent generated by the iron and steel industry, i.e., the Vaughn and Russell model[1], measures the relationship between the availability of fishable waters and participation. Due to the lack of a suitable model to describe the relationship between the availability of fishable waters and effluent from the iron and steel industry, a more generalized approach is used for this part of the analysis. Attention is paid to the observed relationship between fish species and the location of iron and steel plants on the individual river. The likely effects of effluent generated by other sources are analyzed as well.

There are difficulties associated with applying a participation model without using water quality parameters. The problems stem from having to depend heavily on fish species data which is difficult to interpret to determine baseline water quality levels. The "Preliminary Assessment of Projected Water Quality Benefits" report by the Office of Water Regulations and Standards (OWRS) does not provide firm guidelines with which to interpret the fish species data, and interpretations are made below using some very general criteria.

In this study we have used and expanded somewhat on the generalized "Preliminary Assessment" approach, but where difficulties are encountered, estimates of fishing benefits are calculated using alternative baseline scenarios for the availability of different qualities of fishable water. These generate upper and lower bound estimates of potential fishing benefits.

Alternative projection scenarios are also generated by taking into consideration the effect of point source discharges other than the iron and steel industry. These provide upper and lower bound estimates of fishing benefits for the relevant case streams.

Finally, those factors which are important in determining fishing participation but are not accounted for by the model are discussed in the context of the individual rivers. These factors include potential problems of access (to the river) and considerations of aesthetic values.

Both factors are expected to affect increased participation on each of the rivers. (Consideration of aesthetic values are also expected to produce additional benefits to existing users.) Both are therefore used to help determine the most likely point estimate from the upper and lower bound estimates derived from the model.

3.2 Application of the Vaughan and Russell Model

a. Introduction

This study uses the coefficients generated by the Vaughan and Russell model to estimate the change in fishing participation attributable to the expected improvement in water quality.

There are two steps in the Vaughan and Russell procedure. One is the estimation of the change in activity days associated with the various types of fishing and the second, the valuation of those days. To estimate the change in activity days, mean values for the relevant socioeconomic variable for the counties adjacent to each of the three rivers were entered into the regression equations and multiplied by their respective coefficients. Estimated dollar values were then assigned to each projected additional fishing day for each of the three types of fishing to arrive at estimates of benefits.

This procedure is expected to produce fairly reliable benefit estimates. The explanatory variables in the model account for most of the factors identified in the literature as important for projecting demand for fishing. These include characteristics of the population (notably their age, income and sex), the supply of fishable water in the area, the relative supply of different kinds of fisheries, and the average catch of fisherman for different kinds of fishing. By specifying the supply variables in this way, the model captures the effect of locally available substitute sites and congestion.

There are several variables not included in this model, however, which would be expected to affect the demand for fishing in any specific river. These include considerations of access, and aesthetic values. The absence of aesthetic considerations from the model effect the projections in two countervailing ways. First, it may lead to an overestimate of the increase in activity days. Aesthetic considerations (i.e., color odor, and clarity) may actually deter fishermen from increasing their participation inspite of the improvement in potential catch. Second, it underestimates the benefits of utility gains accruing to existing users due to increased pleasure. Since a reduction in effluent is expected to improve the water's odor and general appearance, additional benefits would be created beyond what is measured by a model which only takes fish quality into consideration. While it is important to bear these factors in mind in evaluating the estimates derived from the model, none of the shortcomings mentioned present serious problems to benefit estimation.

The first step in the Vaughan and Russell procedure, i.e., the model used to project activity days, is described below. The valuation of activity days is discussed in some detail in Section 4 (page 86).

b. The Model: Participation Estimation

The important variable in the Vaughan and Russell model is water availability, by fishery type. Supportable habitats are assumed to vary according to water quality changes. To capture the effect of water availability on participation, prediction equations were estimated connecting water availability, by fishery type, with individual decisions.

These decisions included whether or not to fish, what kind of fishing to do, and how many days per year to devote to the several possible types of fishing. The stages of the individual's decisions followed the framework suggested by Cicchetti (1973). In all stages the individual's decisions were hypothesized and found to be sensitive to the availability of water quality suitable for the activity. The stages were:

Stage I. Estimation of an equation for predicting the probability of being a fisherman.

Stage II. Estimation of equations for predicting the conditional probabilities of doing some:

a. Coldwater game fishing (trout),
b. Warmwater game or pan fishing,
c. Rough fishing (carp, catfish) given that one is a fisherman.

Stage III. Estimation of an equation for predicting the average days per angler spent fishing for:

a. Coldwater game fish,
b. Warmwater game fish or pan fish,
c. Rough fish.

Once estimates have been made of the probability of being a fisherman of any sort, P_f, the conditional probability of doing some fishing for species i given that one is a fisherman, $(P_i | P_f)$, and the average days per fisherman per year spent seeking species i, D_i, the estimates of total days per year spent fishing for species i by the population in question is given by:

$$\text{TOTAL DAYS per year} = (\text{POPULATION})\ (P_f)\ (P_i | P_f)\ (D_i)$$

The change in activity days generated by an improvement in water quality is estimated as follows: a change from rough fishing to one of two types of game fishing is projected for the water body(ies) in question. (In the Vaughan and Russell application this change is generated by changes in measured water quality parameters. In this study it is generated by a projected change in fish species) This changes the relative proportion of fishable acreage of the 3 types in the designated area as a whole. Consequently, the probability of being a fisherperson of type A, B, or C is increased or decreased. Further, activity days spent on these three types of fishing changes as a result of the projected change in acreage for each.

The variables used in these several stages of estimation are described in the Appendix, Table 1. The Vaughan and Russell coefficients and their standard errors are summarized in the Appendix, Tables 2 through 4.

c. Application to the Three Rivers

For the purpose of using the Vaughan and Russell model to estimate benefits of BAT regulations for the three case streams, the following assumptions were made:

1. That the coefficients estimated by the Vaughan and Russell model using national data may be applied to the areas of the three rivers. The implication of this assumption is that under the same set of socioeconomic conditions, the behavior of the national sample and the local populations would be similar.
2. That the fisherperson population of the three river areas have the same characteristics (in terms of age, sex,

and income distribution, etc.) as the national population of anglers.

3. Rivers, streams and estuaries with their associated water quality may be catagorized in terms of the type of recreational fishing supported.
4. That the projected BAT water quality level would be suitable for gamefish angling.
5. That counties adjacent to the river segment analyzed constitute the relevant areas of potential demand for the rivers analyzed. Mean values are obtained for their populations and the acreage of recreational water obtained for each river segment.
6. That residents of counties on the periphery of the designated areas of potential demand will be affected by the improvement in water quality of the river in question as well as those living close to it.
7. That the relevant fishing activity changes are those that occur on the case streams. Spillover effects generated by the model are demonstrated but not included in the final benefit estimates.

Assumption 1

The assumption that extrapolations to specific sites may be made from a model using national data may be thought to be the most controversial. A review of the literature on recreation participation demonstrates that recreation values are likely to differ from one area of the country to another. However, the factors which have been found to vary substantially in their importance, notably socioeconomic variables, generate little change in activity days in this model. The change in activity days is determined by the relative and absolute availability of water in each of the three species categories (cold water gamefish, warmwater gamefish and roughfish). This variable (or an equivalent variable) consistently has been found to be most significant in the models analyzed in the literature.

Because the model does not account for either physical impediments to use of the river or aesthetic considerations, it is necessary to discuss the "quality" of the three rivers in terms of these aspects, relative to the quality of alternative sites.

Assumption 2

It was necessary to make this plausible assumption due to the lack of data on the local fisherperson population. These data were used to estimate Stage II (the probability of doing some fishing of a certain type).

Assumption 3

As suggested earlier, it is difficult to categorize a water body using fish species data.[2] Many other variables besides water quality are expected to affect the type and quantity of fish present in any river segment at any point in time. Other important considerations include river flow, bottom sediment, intensity of fishing in the vicinity, stocking, etc. In addition, there is little specific information about the relationship between effluent generated by the iron and steel industry and the presence and quality of fish.

In view of the problems described above, the results generated by the model are used only as guidelines to estimating benefits on individual rivers. On the basis of the "Preliminary Assessment" Report, local riverine conditions, the observed relationships between fish species and the presence of effluent loadings are taken into consideration in estimating benefits.

Assumption 4

The assumption that BAT regulations will increase water quality to a level where it can support warm or cold water sport fishing is based on the present existence of fairly abundant game fish in the reaches of the individual rivers above iron and steel plants. Qualifications to this assumption need to be made where there are other point source dischargers upstream of the river segment analyzed. Otherwise, computed benefits would be overestimated.

Assumption 5

The assumption of specified recreational catchment areas defined on the basis of county boundaries implies that water recreation facilities in the relevant counties are only used by the population in those counties and that the population of those counties only recreates within the defined area. Albeit an obvious oversimplification of reality, the inflow of recreationists into the designated area may be reasonably presumed to be balanced by the outflow. The mix of urban and rural areas around the rivers is likely to assure this pattern. In addition, the size of the catchment areas is also likely to ensure that most of the day trips are internal.

Assumption 6

While population groups on the periphery of the prescribed area are less likely to be affected directly by the increase in fishable water in the three rivers, they will be affected indirectly by the substitution of sites by the population close to the rivers. Sites close to the outlying populations are likely to be less crowded as a consequence.

Assumption 7

The model generates changes in fishing activity in the entire designated catchment area. Consequently, it generates changes in fishing activities in addition to those expected to occur on the river in question. By using this model, an increase in bass acreage may lead to an increase in coldwater sport fishing as well as in bass and rough fishing. The spillover effects i.e., effects which cannot be attributed to changes in activity on particular case streams are not included in the benefit estimates.

d. The Baseline Scenarios--Estimating Existing Fishing Activity

On the basis of observed correlation between iron and steel plants and fish species in the three rivers, the quality of fish species in the river is used as an indicator of the affect of effluent from the iron and steel plant on aquatic life. Information about the quality of species in the three rivers is used to define the baseline numbers and proportions of fishable waters by type.

Difficulties were encountered in using species data to assess quality as mentioned previously. These difficulties included accounting for the effect of other factors affecting fish populations, using data which is old or which does not constitute a representative year, not having the same quality of data for all three rivers, and the absence of data on the condition of the fish sampled.[3]

The following information was available from the data (for all or some of the rivers) and were used to establish baseline scenarios (some, but not all were noted in the draft "Preliminary Assessment of Water Quality Benefits"): the numbers of game fish, the range of species, the number of game fish species and their proportion of the sample by weight.

The absence (or presence) of fishing activity in the river is also an important factor in measuring benefits. The absence of activity suggests that benefits derived from cleaner water would be equivalent to a change from zero fish species to the projected fish species in the river.

By using zero as the baseline, we would be measuring the benefit of a change in perception and, therefore, activity rather than simply a change in "supply." However, it would have to be demonstrated for consistency that the projected change in sports fishing would succeed in changing fishing activity to the equivalent level. In spite of the intuitive appeal of this argument, in the absence of evidence on the relation between the supply of fish and fishing, fishing activity is only used as an indicator of quality in cases where there is some ambiguity in the data on the quality of species present. It is not used to downgrade a river from rough to zero fishing.

The actual categorization of river miles into rough, warm water sport (bass) and cold water sport (trout) fisheries is best described as an attempt to measure a change in quality roughly equivalent to a change from rough to bass or rough to trout. Since many of the fisheries demonstrate quality levels slightly above or below the three categories available in the model it is not always possible to use the categories as any more than average indicators of quality. Thus, for instance, in cases in which there are some stretches of a river which seem to be below rough fishing in quality and others which are above rough fishing but below warm water sport fishing, the average quality is judged to be rough.

The acreage of presently available recreational water is also computed for the baseline scenarios. It was computed by identifying the water bodies used for recreation in the three case study stream areas. These figures are presented in the Appendix, Tables 5, 6 and 7. Since these water bodies were either known as "good" or established fishing areas,[4] they were assumed to be suitable for game fishing.

As a result of the analysis of the data for each river undertaken in the next part of the section, two baseline scenarios are established. Only one river offers alternative scenarios. Scenario 1 assumes that the Mahoning and the Monongahela Rivers are currently rough fishing areas. Under this scenario, the Black River from river mile 0 to river mile 1.5 is categorized as a cold water "game" fishery while the rest of the Black River is categorized as a rough fish area. For Scenario 2, a more reasonable assumption is made, i.e., that the acreage between river mile 22 and 31.5 on the Monongahela is defined as a warm water sport fishery. The other two rivers are defined the same as for Scenario 1.

e. The Projected Scenario

In the projected scenario, current poor quality fishing areas will become game fish habitats when the BAT regulatins are in place. This is based on evidence presented in "Preliminary Assessment of Water Quality Benefits" as well as our findings on: (1) water quality simulated river by river assuming BAT regulations are in place; (2) the presence and number of a variety of water pollutant sensitive species upstream of the segment analyzed or within the portion of the rivers analyzed, and (3) the apparent correlation between current iron and steel discharges and the presence, quantity and range of sport fish species.

An observed correlation between iron and steel plants and fish species type and quantity suggest that the reduction in effluent generated by iron and steel plants will increase the number and variety of game fish downstream of the plants.

Because it is difficult to separate in some cases the effects of other point sources effluent dischargers from iron and steel dischargers, alternative scenarios are presented for the relevant case streams. One scenario generating a lower bound estimate assumes that other point source discharges along the river are cleaned up. Thus the benefits attributable to an iron and steel pollution abatement are net of those that may be attributed to the "clean up" of other point sources.

f. The Generation of Point Estimates

The potential of a particular water body to provide and sustain recreation activity and the likelihood of that potential being realized depends on other factors besides those considered in the model. First, it is necessary to demonstrate that factors other than water quality will not mitigate recreational use of the river. Physical and legal impediments to access, may in the short term at any rate, constrain the full realization of benefits. Second, it is important to demonstrate that there are no negative aesthetic values which may constrain demand or positive aesthetic values which would understate demand. Aesthetic considerations may be identified with survey data, but evidence of the absence of strong negative aesthetic values may be inferred from existing demand. These observations are illustrated river by river.

3.3 The Monongahela

a. Establishment of Baseline and the Projected Scenarios

While the relationship between fish species and water quality parameters is not measured in any systematic way, the draft "Preliminary Assessment" Report by OWRS provides evidence of a correlation between the iron and steel plants, the toxic areas indicated by the water quality simulations, and the number of observed fish species. Furthermore, there is little evidence that other point sources contribute significantly to downstream water quality problems as there are no major dischargers below river mile 29.5, and the power plant at river mile 29.5 does not appear to degrade the water. (In fact there is a warm water fishery at this point.) It is reasonable to impute existing fishing quality, therefore, to effluent loading generated by the iron and steel plants.

The number of species as suggested earlier, is only one indicator of fishing quality. More specific indicators include the number of game fish species, their number and weight. Nevertheless, the variability of the number of species within the 50 mile portion of the lower river segment, suggests that iron and steel discharges have a significant effect on this number. Table III-6 demonstrates this observed relationship. It shows that a small number of species is roughly correlated with the highest number of plants within 5 miles upstream.

Data on the range and quality of species sampled between 1976 and 1978 substantiates the above findings. It is presented in Table III-7. Quality

Table III-6

Total Number of Fish Species Observed Along the Monongahela River[1] (Based on Fish Surveys in 1976, 77 and 78

	RM 11.2	RM 11.6	RM 13-16	RM 22-31.5	RM 33.2-	RM 42
Number of Species Observed[2]	11	23	11/9	23/46	9	5
Number of Steel Facilities Within 5 Miles Upstream	3	2	3	0	1	0

[1] This table is complied from table 3-7 in the "Preliminary Assessment of Water Quality Benefits". Other samples were added.

[2] Between River Mile 12-16 and 22 to 31.5 two samplings were recorded.

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designators are based on those used in the Vaughan and Russell study. The number and type of species caught at river mile 11.2, where there are 3 facilities upstream, strongly contrast with the number and type caught between river mile 22 to 31.5 where there are none. Further, in view of the fishing activity in the latter reach of the river, it is reasonable to postulate that the total number of fish species observed from river mile 22 to 31.5 suggests the presence of a warm water game fishery.[5]

Evidence of the presence and type of fish species without evidence of their number and weight may be misleading, however. Only limited information is available for this river. Table III-8 presents a summary of fish sampling on two stations along the Monongahela from 1967 to 1973 and from 1976 to 1980; an upstream site (above our section) and a downstream site (lock and dam no. 2 river mile 11). This demonstrates that the percent of sensitive species by weight at the upstream site is consistantly higher than at lock and dam 2.[6,7,8]

It may be inferred from the above that the presence of warm water species in the downstream segment is not sufficient to categorize it as a warm water fishery. The fairly good potential of this fishery on the other hand may be inferred from the quality of the species in the upstream sample. The likelihood of this river becoming a warm water fishery, if BAT regulations are in place is comfirmed by the OWRS water quality simulations.

In conclusion, the Monongahela River between river mile 0 and 44 may be categorized as a rough fishing area for a lower bound water quality estimate (Scenario 1). This yields an upper bound benefit estimate. In Scenario 2, the river is categorized as rough, except for the segment between river mile 22 and 31.5 which is considered suitable for warm water gamefish. This yields a lower bound benefit estimate. The reduction of effluent from the iron and steel industry is expected to improve fishing to the category of warm water "sport" fishing along the entire 44 mile stretch under both scenarios.

b. Estimates of New Activity Days, Scenarios 1 and 2

The changes in activity days associated with a change from rough fishing to warm water game fishing are indicated below. The actual calculations are presented in the Appendix, Table 9. Additional days spent fishing totaled 477,111. They were divided between rough, warm water and cold water game fishing.[9] Under the second scenario (where a smaller section of the river is designated as rough in the baseline) total fishing activity days are projected to increase by 360,000 days.

	Scenario 1	Scenario 2
New[10] Bass Activity Days	72,885	60,080
New Trout Activity Days (excluded below)	172,025	105,955
New Rough Activity Days	232,201	194,315
Total	477,111	360,240

Benefit computations[11] are presented in Table III-7. Under Scenario 1, benefits are $6.7 million ($11.7 million including trout days); under Scenario 2, benefits equal $5.6 million ($8.6 million including trout days).

Table III-7

Estimated Benefits (Million 1981 $)

	Scenario 1	Scenario 2
New Bass Activity	$ 1.9	$1.6
New Trout Activity	4.9	3.0
New Rough Activity	4.8	4.0
Total	$11.7	$8.6
Warm Water Fishing (excludes trout)	$ 6.7	$5.6

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c. Establishment of Point Estimates--Access and Aesthetic Considerations

The identification of reasonable point estimates is undertaken based on considerations of accessibility and aesthetic values.

There do not appear to be significant access problems on the Monongehela river for boat fishing or riverside fishing. The lower section of the Monongahela, is lined with small towns, factories and railway tracks. There are access problems in some places particularly where there are factories. Since towns are situated directly on the river, however, there are many spots where it is possible to reach the river bank. In addition there are many boating facilities along the river as demonstrated in Table III-10. Although there are relatively few on the Monongahela compared with other rivers in Allegheny county,[12] they are not so far apart that they would not permit access to all parts of the river.

Furthermore, the development plans of Allegheny county identified 12 potential locations for development along the Monogehela river[13]. While

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Table III-8

Fish Species by Type and Location in Relation to Steel Plants

River Mile & Sampling Date	Fish Species & Plant Location	Type of Fish Species
River Mile 11.2 (1978)	THREE STEEL PLANTS	
	Fathead Minnow	R*
	Bluntnose Minnow	R
	Channel Catfish	R
	White Catfish	R
	Pumpkinseed	WG**
	Gizzard Shad	
	Carp	R
	Emerald Shiner	
	Spotfin Shiner	
	Sand Shiner	
	Mimic Shiner	
River Mile 13-16 (1976)	TWO STEEL PLANTS Mouth of Youghegeny	
	Carp	R
	Goldfish	R
	Fathead Minnow	R
	Bluntnose Minnow	R
	Rock Bass	WG
	Largemouth Bass	WG
	Smallmouth Bass	WG
	Green Sunfish	WG
	Yellow Perch	WG
17-22 River Mile 22-31.5 (1978)	TWO STEEL PLANTS	
	Silverjaw Minnow	R
	Bluntnose Minnow	R
	Flathead Minnow	R
	Channel Catfish	R
	White Catfish	R
	Yellow Bullhead	R
	Brown Bullhead	R
	Rock Bass	WG
	White Crappie	WG
	Black Crappie	WG
	Largemouth Bass	WG
	Smallmouth Bass	WG
	Green Sunfish	WG
	Pumpkinseed	WG
	Bluegill	WG
	Bluegill Hybrid	WG

Table III-8 (continued)

River Mile & Sampling Date	Fish Species & Plant Location	Type of Fish Species
	Yellow Perch	WG
	Walleye	WG
	Logperch	WG
	Johnny Darter	R
	Greenside Darter	R
	Fantail Darter	R
	POWER PLANT	
33.2 (1976)	Yellow Bullhead	R
	Brown Bullhead	R
	Rock Bass	WG
	Black Crappie	WG
	Largemouth Bass	WG
	Pumpkinseed	WG
	Bluegill	WG
	Muskellung	WG
	Carp	R
	Goldfish	R
33.4 (1976)	Yellow Bullhead	R
	Rock Bass	WG
	Largemouth Bass	WG
	Smallmouth Bass	WG
	Green Sunfish	WG
	Pumpkinseed	WG
	Bluegill	WG
	Carp	
	Goldfish	
	STEEL PLANT	
42 (1977)	Smallmouth Bass	WG
	Green Sunfish	WG
	Pumpkinseed	WG
	Fathead Minnow	R
	Bluntnose Minnow	R

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*R = Roughfish
**wg = Warmwater Gamefish

Source: Pennsylvania Fish Commission, various years.

Table III-9

Summary of Fish Sampling, Monongahela River[1]

1967 - 1973 1976 - 1980

	1967	1968	1969	1970	1973	1976	1977	1978	1980
Maxwell Lock (1.4 surface acres)									
Total number fish	0	1	204	54	8071	1664	1158	5208	
Total weight fish (lbs.)	0	0.04	6.43	6.76	91.50	109.53	98.17	180.39	
Number of species	0	1	8	6	16	19	20	22	
Percentage sensitive species (by weight)			18	23	65	32	48	38	
Lock No. 2 (.5 surface acres)									
Total number fish	20	207	1626	261	869	754	6363	2103	1148
Total weight fish (lbs.)	2.58	27.33	58.33	45.70	74.48	8.64	252.81	90.72	507.39
Number of species	4	8	12	12	16	14	19	12	20
Percentage sensitive species (by weight)	26	9	6	12	31	29	8	7	7

Source: U.S. Environmental Protection Agency Region III, Pennsylvania.

11 of these were found to be unsuitable because of physical access and/or ownership constraints, it was the stated objective of the Allegheny County Comprehensive Recreation and Conservation Plan published in 1977 to develop these sites, returning the river to public use. Subsequent development of the area both by the public and private bodies suggests that access problems that may be a barrier to development are being removed.[14] In addition, with some industries and population already moving away from the river, more development land is being made available for recreation.

Aesthetic considerations do not seem to pose problems for the development of recreation of the Monongehela. Neither would they suggest that measured benefits would underestimate potential benefits to new user days. The increase in recreation activity during the 1970's further suggests that aesthetic considerations do not decrease the potential of the site for recreation. Many towns along the river have cleaned up unsightly sludge along their stretch and have developed recreation facilities by the river edge.[15] On the other hand, we cannot argue that the site is of unusual aesthetic beauty and would attract anglers for this primarily.

In conclusion, there do not appear to be any reasons why the estimates produced by the model is likely to be systematically biased upwards. There may be, on the other hand, some downward bias as a result of the model's inability to account for aesthetic benefits to existing user days.

3.4 The Mahoning River

a. Establishment of Baseline and Projected Scenarios

The relationship between fish species data and dischargers of phenol, ammonia and cyanide data, has been documented in a biological survey concluded

Table III-10
Recreational Docks and Launching Ramps Along the Monongahela River--Pennsylvania

Facility	Rm
City of Pittsburgh Ramp	0.5
South Hills Boat Club	7.0
Berties Landing	Yough. R.
Surfside 4	Yough. R.
Pa. Fish Commission Ramp	Yough. R.
McKeesport Boating, Inc.	15.7
Monongahela Valley Speedboat Club	15.8
Dravosburg Boat Club	16.5
Valley Boat Club	18.5
Elizabeth Boat Club Ramp	22.9
Evan Ford	26.2
Pine Run Outboard Club	26.4
Evan Ford	26.7
Carmac Sales Co.	27.9
John Moilnar	28.9
Samuel P. Yohe	31.4
Mon. Public Ramp	31.8
Mon. Mariners Public Ramp	31.8
Mon. City Aquatorium	31.9
Mon. Public Ramp	31.9
Hanna's Harbor	33.0
Long's Boat Dock	33.1
Pa. Fish Commission Ramp	33.2
Mancini's Boat Center Ramp	33.2
Frances C. Long	33.4
Webster's Boat Club	36.3
Borough of Charleroi Ramp	42.3
Virgin M. Dudes	43.3
Boat Shop & Marina	43.4
Pa. Fish Commission Ramp	43.3
Joseph Barcelona	44.3
Brice Ray	44.4
Charleroi Boat Club Ramp	44.5
Luzerne Coal Corp.	45.2

Source: "The Preliminary Assessment of Projected Water Quality Benefits from Implementation of the Proposed Regulations Defining Best Available Technology Economically Achievable for the Iron and Steel Industry."

by the Ohio EPA in 1980 and presented in the "Preliminary Assessment of Water Quality Benefits". The data are presented here for completeness. They demonstrate that the potential range of species upstream of the steel plants is fairly large and, therefore, can be categorized as a warmwater game fishery. The data also illustrate a fairly strong relationship between species diversity (total and sport) and the number and the location of dischargers along the river. This implies that the reduction of dischargers will improve fishing to the point where it can be categorized as a warmwater fishery. Because of the effects of sewage treatment plants (STP) in the vicinity,[16] however, it is expected that only part of the benefits will be realized unless STP treatment is upgraded. This is taken into consideration in the calculation of benefits. Benefits are attributed to sources of pollution on the assumption of proportionality.[17]

The species data demonstrates a fairly large number of sports species currently in the river segment of study. However, the year for which the data was obtained, 1980, was an unusually low steel production year which may explain the presence of sport species in this segment. Also for the most part the sport species found were deformed and small in size. Since this portion of the river is not fished and there is some ambiguity in the fish species results, this river is currently categorized as "rough" rather than "sport."

b. Estimates of New Activity Days, Scenarios 1 and 2

The projected changes in activity days for the Mahoning are indicated below. Benefit results are presented using two assumptions:

1. That the STP's are cleaned up and that all benefits are attributed to the BAT regulations; and

2. That the STP's are not cleaned up and that only partial improvement of the water occurs. (This is the same as attributing only part of the benefits of cleaning up all sources to the BAT regulations).

Estimated New Activity Days

	Scenario 1	Scenario 2
New Bass Activity Days	5,998	3,374
New Trout Activity Days	34,377	22,224
New Rough Activity Days	11,129	6,774
Warm Water Total (Trout excluded)	17,127	10,148

Benefit estimates are presented below. Total benefits are estimated at $0.39 million per year for warm water (game and rough) fishing and $1.38 million in total fishing benefits. Under the second scenario, $0.25 million for warm water fishing (and $0.87 million for total fishing) would be attributed to the BAT regulations.[18]

Estimated Benefits

(Millions of 1981 $)

	Scenario 1	Scenario 2
New Bass Activity	$ .16	$.09
New Trout Activity	.99	.64
New Rough Activity	.23	.14
Total	$1.38	$.87
Warm Water Fishing (trout deleted)	$ .39	$.25

c. Establishment of Point Estimates, Access and Aesthetic Considerations

Access and aesthetic considerations are closely associated on stretches of the Mahoning, particularly around the steel plants. While only 5.5 miles[19] are considered to be non-navigable by boat, stretches of the banks of the Mahoning are inaccessable for boating or for river bank fishing. Those stretches which are particularly inaccessible do not seem to have any positive aesthetic value (i.e., they are primarily areas in which the steel plants line the river bank).[20] For these reasons, the relatively low fishing benefits estimates above would be appropriate for the Mahoning.

3.5 The Black River

a. Establishment of the Baseline and Projected Scenarios

Fish sampling was undertaken on five stations within the study area in 1977. Table III-11 presents the results of this sampling for stations by species caught. (Station 1506 was upstream of the study area.)

The composition of 24 species taken two miles downstream of the U.S. Steel facility (USSC, at river mile .05) indicates that the greater number of species is in part due to the presence of fish characteristic of lake, pool and large river habitats. Characteristic lake species found at the downstream station include the Sea Lamprey, the Alewife and Rainbow Smelt, Gizzard Shad and the Emerald Shiner. Coho Salmon was also found in this sample. Since none of these species were found at the next five sites upstream, the diverse fish community downstream is attributed to the movement of fish up the mouth of the river from Lake Erie.

As indicated in the "Preliminary Assessment of Water Quality Benefits", the adjacent tributaries (i.e., Rocky and Vermillion Rivers) have a more diverse population of desired species than does the Black River. The adults from to Lake Erie then migrate up the tributaries in an attempt to reproduce. Desirable species such as the Coho Salmon and Rainbow Trout are also currently being stocked in these other rivers. They could presumably also be accommodated in Black River upon substantial improvement in the water quality.

The results of the fish study clearly demonstrate a lower diversity of fish between USSC at Lorain and the Elyria STP than exists at river mile 0.5 and at river mile 10. This and the evidence of fish migrating up adjacent streams suggest that existing conditions (water quality) are such that they inhibit passage of desirable species upstream. The absence of these species upstream appear to be due, therefore, to the high levels of toxic and thermal discharges from USCC. Some, further inhibition may be caused by a small an abandoned mill dam at River Mile 11.

In addition, the Elyria STP currently discharges enough ammonia and BOD to prevent free movement of fish past its outfall. The STP in accordance with the final permit limitations is required to upgrade its facility to provide improved wastewater treatment for ammonia and BOD.

Efforts are also underway to develop a pretreatment program which will substantially reduce or eliminate the inflow of toxics from industrial waste. After these two modifications are realized, it is anticipated that the Elyria STP will not significantly affect water quality, thereby allowing the free flow of fish species.

Table III-11

Fish Species Caught in 1977 Survey Stations 1501-1506

Station 1502	Station 1502	Station 1503	Station 1504	Station 1505	Station 1506
Sea Lamprey	Gizzard Shad	White Sucker	Carp	Common White Sucker	Northern Hog-Sucker
Alewife	White Sucker	Carp	White Sucker	Carp	Common White Sucker
Rainbow Smelt	Carp	Goldfish	Golden Shiner	Golden Shiner	Northern Redfin Shiner
Eastern Gizzard Shad	Gold Shiner	Northern Creek Chub	Northern Creek Chub	Northern Redfin Shiner	Striped Shiner
Emerald Shiner	White Bass	Common Shiner	Spot Fin Shiner	Sand Shiner	Spotfin Shiner
Coho Salmon	White Crappie	Fathead Minnow	Fathead Minnow	Northern Fathead Minnow	Sand Shiner
Silver Lamprey	Large Mouth Bass	Stone Roller	Blunt Nosed Minnow	Bluntnose Minnow	Silverjaw Minnow
Common White Sucker		Brown Bullhead		Yellow Bullhead	Brown Bullhead
Carp				White Crappie	Black Bullhead
Goldfish				Black Crappie	White Crppie
Striped Shiner				Northern Largemouth Bass	Black Crappie
Spottail Shiner				Green Sunfish	Northern Rock-Bass
Northern Fathead Minnow				Northern Bluegill	Northern Small mouth Bass
Bluntnose Minnow				Pumpkinseed	Northern Largemouth Bass
				Greenside Darter	Green Sunfish
				Northern Creek Chub	Northern Blue-Gill
				Striped Shiner	Greenside
				Ohio Stoneroller Minnow	
				Northern Smallmouth Bass	

Source: NOACA.

It is difficult, however, to separate the effect of the Elyria STP and the USSC on species composition. The Elyria plant seems to inhibit migration downstream (note the reduction in species downstream of the Elyria plant) but it also seems, in combination with the USSC plant, to restrict the flow of fish upstream. (The contrast of species between stations 1501 and 1502 suggests the importance of the inhibiting effect of the USSC plant on upstream migration.) The benefits of facilitating the flow upstream would therefore seem to be appropriately divided between action on the two plants. Any improvement on downward migration would be attributable to the Elyria plant only.[21]

In order to compute the benefits from improving the steel plant only (i.e., the lower bound estimate) it is necessary to assume that the fish composition of the segment between the steel plant and the STP plant is, in the baseline scenario, similar to the current composition upstream of the STP plant (i.e., it is assumed that the STP is not cleaned up.)[22] Although there is relatively little information on the species present in this upstream segment, it is known to contain 19 species of fish, including 7 species of game fish. This is generally an indication of fairly good fishing. However, it would be misleading to characterize this fishing area as a "sport" fishery which, therefore, would not produce any measured benefits from water quality improvement. Even with a fairly good distribution of species from upstream, it would be unreasonable not to include in the benefit estimate the potential beneficial effect of the kinds of species such as salmon that would migrate upstream if effluent from the steel plant and the STP plant were reduced. Indeed, the presence of trout and salmon fishing downstream of the steel plant clearly indicate the potential benefits to be obtained.

In view of the above, it seems reasonable to postulate an improvement in fishing from river mile 2.5 to the Elyria plant equivalent to an improvement from rough to trout even though the baseline may be higher than rough.

It should be noted that fishing is known to take place in the lower 12 miles of the river suggesting that the benefits to be derived from the regulation would come primarily from a change in the species present in the river and that there are unlikely to be additional benefits hitherto unaccounted for. However, any overestimation that might occur because of the designations would be balanced by potential benefits to tributaries of the Black River (from fish moving upstream) not computed in this study (for example, the migration of Salmon up French Creek).

b. Estimates of New Activity Days, Scenarios 1 and 2

The projected change in activity days in the Black River is indicated below:

Change in Trout Activity Days	+150,500
Change in Rough Activity Days	- 74,318

As indicated above the increase in trout activity days is balanced somewhat by the decrease in rough activity days. A net increase in benefits of $2.83 is computed (Scenario 1). $2.35 of these benefits may be attributed to the Iron and Steel regulations. (Scenario 2)[23]

Estimated Benefits

(Millions of 1981 $'s)

	Scenario 1	Scenario 2
New Trout Activity	$ 3.58	$ 4.37
New Rough Activity	- 1.23	-1.53
Total Cold Water Sport and Rough Fishing	$ 2.35	$ 2.83

c. Establishment of Point Estimates, Access and Aesthetic Considerations

The Black River has no access or aesthetic problems that would inhibit an increase of fishing activity on the river. While portions of the lower segment of the river--the lower 6.5 miles-are lined with factories, it is possible to reach the river bank. There are boat ramps and marinas along this stretch. Some boating already occurs in this area of the river. Aesthetically, some stretches of the lower region are not particularly attractive, but this is not expected to negatively affect participation. In addition, any negative aesthetic values should be weighed against positive values in the upstream reach and improvements in key tributaries such as French Creek. These spillover benefits, which could be substantial, have not been calculated here.

FOOTNOTES

1. This model is taken from an April 1981 draft report prepared by Vaughn and Russell at Resources for the Future. It is not available in final form at this time.

2. Discussions with fish biologists indicated some of the issues involved. The complexity of these issues suggested caution should be used in intrepreting the data.

   A particular problem is categorizing fish species observed in the respective rivers by fishery type. For instance, the presence of warm water game fish on a river sample is not necessarily an indicator of a good uality fishing area. On the other hand, the presence of a large number of sport fish on a river reach might suggest it is a good fishing area. The number of species is only a partial indicator since this number may decline down stream for other reasons. In addition, the proportional weight of pollutant resistant species in a sample may be misleading because it is effected by upstream fishing intensity. (Ohio EPA)

3. This last ommission could result in an incorrect interpretation of data, if not accounted for in some way. The effect of phenol would not be noticed in sampling because it is not toxic. Its primary effect on fish is on its taste (rather unpleasant). In addition, ammonia, while causing fish kills in some cases also causes a spinal disease which causes fish to lose their fins and have crooked backbones. Marine biologists involved in the sampling of the Mahoning have emphasized the number of diseased, deformed and undersized fish (Ohio EPA).

4. It was not possible to present accurate estimates of acres of fishing for all rivers. They were available for Lorain County and for the Mahoning region. They were estimated for the Monongahela.

5. It should be noted that although there have been warm water game fish sampled between river miles 13 and 16, this fishing represents a limited good fishing spot. This seems to be due primarily to the entrance of the Youghegehny River.

6. Sensitive species defined in this survey were almost identical to the species defined in the Vaughan and Russell study. For this reason, the two terms may be used synonymously.

7. The two of the three years that the percent of sensitive species was up at Lock and Dam No. 2 may be explained by the small sample size collected.

8. It is noted that both upstream and downstream sites demonstrate an improvement over time in increased poundage and number of species. The improvement at Maxwell may be directly attributable to acid mine treatment and abatement. The slight improvement at Lock and Dam No. 2 may also be a result of this. Reduction of effluent from the iron and steel plants is expected to improve species distribution and weight further.

FOOTNOTES (cont.)

9. The Russell and Vaughan model measures the increase in fishing activity in the region as a whole as a result of reducing iron and steel effluent in the Monongehela rather than simply the increase in fishing in the Monongehela itself. Thus, an increase in the supply of warm water sport fisheries may also generate an increase in cold water sport fishing activity elsewhere in the region. Similarly the increased Bass days may not occur only in the Monongehela.

10. Benefits to new activity days include benefits accruing to additional user days and to those who change existing fishing activity days spent on rough fishing to warm water sport fishing. From the results generated above, it may be noted that a large proportion of the benefits are generated by an increase in fishing days spent on all types of fishing. Thus, it may be construed that the increase comes largely from an increase in days, rather than in transfers.

11. Charbonneau and Hay (1978) estimates for the values of a fishing day are used. They are very similar to Vaughan and Russell's estimates. Rough fishing days are valued at $20.70, bass at $26.27, and trout at $29.04.

12. There are only 15 such boating ramps compared with 27 on the Allegheny (which has approximately the same river mileage in Allegheny County as the Monongahela) and 15 on the Ohio (which is approximately half the length), according to Allegheny County Comprehensive Recreation and Conservation Plan 1977.

13. The Allegheny County Comprehensive Recreation and Conservation Plan 1977.

14. "Life Again Along the Monongahela River," Draft, Bureau of Outdoor Recreation, Philadelphia, PA.

15. Ibid.

16. The OWRS simulations showed that Ohio's warm water habitat standards for ammonia and BOD cannot be obtained unless STP's are upgraded to comply with their permit standards.

17. Downstream from Youngstown, two-thirds of the benefits are attributed to BAT regulations. We make the assumption that only half of the benefits computed beyond the Warren STP to Youngstown are attributable to the BAT regulations.

18. This amounts to approximately .65 of the total benefits for the river.

19. See Section 4 of this document.

20. No part of the Mahoning is expected to have outstanding aesthetic value. Thus, there would be no underestimate of benefits from the model.

FOOTNOTES (cont.)

21. Most benefits from stocking trout on tributaries of the Black would also accrue primarily to the STP plant, but are not included here.

22. We also present estimates which impute all the benefits to the shift at the steel plant to BAT. This is known as Scenario 2, in which it is assumed that the STP is controlling its pollution. This would enable rehabilitation of the entire river by Coho salmon once the steel plant upgraded its treatment. The two scenarios illustrate the difficulty of the "joint product" problem, namely that water quality benefits are difficult to attribute to individual discharges if more than one polluter affects a specific body of water.

23. The high proportion of benefits calculated attributable to the BAT regulations is because most of the benefits accrue to downstream species where the river is much wider than upstream.

Appendix - Table 1: Dependent and Independent Variables Used in Stage I,II and III Equations

A. DEPENDENT VARIABLES

Name	Description	Source	Stage Used
FISH	Binary Choice 1 if Fisherman; 0 if otherwise	NSHFWR Phone	I
TMAN	Binary choice of doing "some" coldwater gamefish angling or not. Equal to: 1, if any days spent coldwater gamefish angling 0, otherwise	NSHFWR Mail	II
BPMAN	Binary Choice of doing "some" warmwater gamefish/panfish angling or not. Equal to: 1, if any days spent warmwater gamefish/panfish angling or not. Equal to: 0, otherwise	NSHFWR Mail	II
CMAN	Binary choice of doing "some" roughfish angling or not. Equal to: 1, if any days spent roughfish angling 0, otherwise	NSHFWR Mail	II
TROUTDA	Days spent per person per season fishing for coldwater gamefish in freshwater (i.e., not including days spent on the Great Lakes or saltwater) for fishermen with TMAN = 1.0	NSHFWR Mail	III
BAPADA	Days spent per person per season fishing for warmwater gamefish/panfish in freshwater (i.e., not including days spent on the Great Lakes or saltwater) for fishermen with BPMAN = 1.0	NSHFWR Mail	III
ROUGHDA	Days spent per person per season fishing for roughfish (i.e., not including days spent on the Great Lakes or saltwater) for fishermen with CMAN = 1.0	NSHFWR Mail	III

B. INDEPENDENT VARIABLES

Name	Description	Source[a]	Stage Used
INCM	Respondent's household income, 1975 dollars	NSHFWR Phone, Mail	II, III
AGE	Respondent's age, years	NSHFWR Phone, Mail	I, II, III
AGESQ	AGE squared	NSHFWR Phone, Mail	I, II, III
SEX	Dummy variable for sex: 0 = male; 1 = female	NSHFWR Phone, Mail	I, II, III

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Appendix - Table 1 (cont.)

B. INDEPENDENT VARIABLES (cont'd.)

Name	Description	Source	Stage Used
METRO	Dummy variable to indicate if respondent lives in a metropolitan or non-metropolitan area: 1 = metro resident; 0 = otherwise	NSHFWR Phone, Mail	I, II, III
INCPER	Average income per household member (i.e.: Household income divided by persons per household)	NSHFWR Phone, Mail	I
HEAD	Dummy variable to indicate if respondent is Head of Household 1 = Head of Household; 0 = otherwise	NSHFWR Phone, Mail	I
PREF	Dummy variable to indicate the intensity of preference for fishing of any sort over other wildlife-associated recreational activities: 1 = fishing is favorite activity; 0 = otherwise	NSHFWR Mail	III
WEST	Dummy variable for residence in Census West Region: 1 = live in West; 0 = otherwise	NSHFWR Phone	I
CENT	Dummy variable for resident in Census Central Region: 1 = live in Central; 0 = otherwise	NSHFWR Phone	I
SOUTH	Dummy variable for resident in Census South Region: 1 = live in South; 0 = otherwise	NSHFWR Phone	I
COAST	Dummy variable to indicate whether the respondent's state has a marine and/or Great Lakes coastline or not: 1 = marine and/or Great Lakes coastline: 0 = otherwise	Maps	I, II, III
INACRE	Total acreage of fishable non-Great Lakes freshwater per capita in respondent's state. A measure of the availability of in-state supply	Hatchery Fish	I
OUTACRE	1, if fishable acres per capita in Bordering States exceeds INACRE; 0, otherwise [2]	Hatchery Fish	I
TBAG	Average number of coldwater gamefish caught per fishing day by respondents favoring the activity, 11 regional averages	NSHFWR Mail	II, III
BPBAG	Average number of warmwater gamefish/panfish caught per fishing day by respondents favoring the activity, 11 regional averages	NSHFWR Mail	II, III

Appendix - Table 1 (cont.)

B. INDEPENDENT VARIABLES (cont'd.)

Name	Description	Source	Stage Used
CBAG	Average number of roughfish caught per fishing day by respondents favoring the activity, 11 regional averages	NSHFWR Mail	II, III
RFFBPSHR	Ratio of fishable freshwater acreage in respondent's state suitable for warmwater gamefish/panfish angling to total state fishable acreage, all species	RFF Survey[c]	II
RFFRSHR	Ratio of fishable freshwater acreage in respondent's state suitable only for roughfish angling to total state fishable acreage, all species	RFF Survey[c]	II
RFFTRAC	Fishable freshwater acreage per capita in respondent's state suitable for coldwater gamefish angling.	RFF Survey	III
RFFBPAC	Fishable freshwater acreage per capita in respondent's state suitable for warmwater gamefish/panfish angling.	RFF Survey	III
RFFRAC	Fishable freshwater acreage per capita in respondent's state suitable only for roughfish angling.	RFF Survey	III

---

[a] Sources

NSHFWR Phone:	U.S. Fish and Wildlife Service. 1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation (Data Tape, Telephone Interviews).
NSHFWR Mail:	U.S. Department of the Interior, Fish and Wildlife Service. 1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation. Mail Interviews (Data Tape).
Hatchery Fish	U.S. Fish and Wildlife Service. 1968. National Survey of Needs for Hatchery Fish, 1965. This source estimates, state-by-state, the available acres of fishable freshwater as discussed in Chapter 2.
RFF Survey	Resources for the Future. 1980. RFF Fishable Water Survey (Unpublished Data).
RFFWQNM	Leonard P. Gianessi and Henry M. Peskin, and G.K. Young. Forthcoming 1981. "Analysis of National Water Pollution Control Policies: I. A National Network Model." Water Resources Journal.

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Appendix - Table 2

Stage 1

Probability of Fishing Participation ("t" statistics in parentheses)

REDUCED MODEL I[a]

VARIABLE	COEFFICIENT		PARTIAL DERIVATIVE
INTERCEPT	-1.07754 (8.60)*		...
AGE	0.05515 (9.99)*		0.01110
AGESQ	-0.00078 (11.15)*		0.00016
SEX	-1.2568		-0.25197
METRO	-0.30606 (5.16)*		-0.06161
WEST	0.43279 (4.89)*		0.08712
CENT	0.53004 (6.67)*		0.106870
SOUTH	0.40777 (5.20)*		0.08209
INACRE	0.89064 (6.91)		0.17929
INCPER	0.0000079 (1.14)		0.0000016
HEAD	-0.17346		-0.03492
COAST			-0.02680
Chi-Square Test		814.08*	
Likelihood Ratio Index		0.086	
Probability of Fishing Evaluated at Means[a]		0.279	

Appendix - Table 2 (cont.)

Stage 1

Probability of Fishing Participation
("t" statistics in parentheses)

Note: An asterisk (*) indicates significance at the 5 percent level.

[a] A Logit equation of the form:

$$P_f = P_{FISH} = \frac{1}{1{+}e - (\text{INTERCEPT}) + \sum_{i=1}^{n} \beta_i \overline{X}_i \ )}$$ Actual sample frequency is 0.303.

n = 7760. OUTACRE with a t-statistic of zero, was eliminated from the full model.

[b] The partial derivative of the Logit model is $p/\ X_i = p(1-p)\ _i$ where p is the probability of participation and $_i$ is the estimated parameter of the i^{th} independent variable, X_i.

Appendix - Table 3

Stage II

Probability of Doing Some Fishing for Particular Species Groups[a]

(t statistics in parentheses)

	TYPE OF FISHING		
Variable	Some Trout Fishing	Some Bass Fishing	Some Rough Fishing
INTERCEPT	0.947 (25.52)*	0.4399 (12.12)*	0.3401 (9.17)*
INCH	0.0000006 (1.45)	-0.000002 (4.98)*	-0.000003 (7.83)*
AGE	-0.0038 (2.42)*	0.0013 (0.83)	-0.0047 (3.05)*
AGESQ	0.000021 (1.11)	-0.000048 (2.61)*	0.000009 (0.46)
SEX	-0.0466 (3.54)*	-0.773 (6.07)*	-0.0213 (1.64)
METRO	-0.174 (1.70)	-0.0479 (4.82)*	-0.0592 (5.84)*
COAST	-0.0901 (5.72)*	-0.0129 (0.99)	-0.1517 (11.41)*
TBAG	0.0336 (6.21)*	-0.0155 (2.94)*	0.0076 (1.42)*
BPBAG	-0.0178 (15.86)*	0.0056 (5.19)*	0.0073 (6.53)
CBAG	0.0037 (1.04)	-0.0002 (0.05)	0.0139 (3.92)
RFFBPSHR	-0.5927 (12.81)*	0.3996 (8.90)*	0.2190 (4.78)*

Appendix - Table 3 (cont.)

Stage II

Probability of Doing Some Fishing for Particular Species Groups[a]

(t statistics in parentheses)

	TYPE OF FISHING		
Variable	Some Trout Fishing	Some Bass Fishing	Some Rough Fishing
Degrees of Freedom	9974	9972	9972
F Ratio	100.93*	91.66*	100.83*
R^2	0.0835	0.0918	0.1001

Note: An asterisk (*) indicates significance at the 5 percent level.

[a] These are linear WLS equations, using observations and population weights from the NSHFWR mail survey tapes, N = 9986.

Appendix - Table 4

Days of Participation per Season Equations by Species Sought by WLS from the Larte Unproportional Mail Survey Sample After Outlier Deletion

	PARAMETER ESTIMATES		
DEP VAR:	TROUTDA	BAPADA	ROUGHDA
INTERCEPT	8.3626 (7.75)*	12.3758 (9.40)*	9.7833 (11.24)*
AGE	0.2241 (4.46)*	0.2084 (3.54)*	-0.0198 (0.50)
PREF	0.7645 (2.40)*	1.9462 (5.36)*	0.2589 (1.04)
AGESQ	-0.0023 (3.73)*	-0.0019 (2.62)*	0.0066 (1.30)
SEX	-2.9643 (6.66)*	-4.5193 (8.71)*	-0.9890 (2.88)*
METRO	-0.9405 (2.76)*	-0.8394 (2.33)*	-0.9793 (3.96)*
INCH	-0.0008 (6.14)*	-0.00010 (6.31)*	-0.00006 (5.60)*
COAST	-0.0316 (0.08)	-0.3340 (0.71)	-1.2177 (4.25)*
TBAG	0.25676 (2.26)*	-0.7088 (3.28)*	-0.4990 (2.89)*
RFFTRAC	7.0472 (7.67)*	-4.4004 (2.45)*	-4.1686 (2.96)*
BBAG	-0.0765 (1.84)	0.0980 (2.38)*	0.922 (3.14)*
RFFBPAC	-8.6298 (5.21)*	7.5352 (3.77)*	2.0436 (1.46)
R^2	0.0417	0.0345	0.0471
F	15.89*	15.87*	11.63*

Appendix - Table 4 (cont.)

Days of Participation per Season Equations by Species Sought by WLS from the Larte Unproportional Mail Survey Sample After Outlier Deletion

	PARAMETER ESTIMATES		
DEP VAR:	TROUTDA	BAPADA	ROUGHDA
Cases Deleted	213 of 4965	274 of 6066	161 of 3232
Percent Deleted	4.3	4.5	5.0

Note: An asterisk (*) indicates significance at the 5 percent level.

Appendix - Table 5

Fishing Areas
Monongahela River

County		Area
Allegheny	North Park	75 acres
	Allegheny River	2608 acres[1]
	Renzie Park	1 acre
	Hampton Community Park	1.5 acre
	Clairton Park	0.5 acre
	Ross Community Park	1 acre
	Deer Lakes Park	8 acres
	Ohio River	1,570 acres
Fayette	Ohiopyle	1 mile
	Dunlap Creek Reservoir	101 acres
	Virgin Run Lake	37 acres
	Youghegheny Reservoir	2,840 acres
	Greenlick Reservoir	102 acres
	Dunlap Creek Reservoir	101 acres
	Star Junction Reservoir	5 acres
	Monongehela River	2,752 acres
Washington	Mingo Creek	4 miles
	Aunt Clara Fork	4 miles
	Bentlyville Municipal Dam	5 acres
	Dutch Fork Creek	3.5 miles
	Enlow Fork	4.7 miles
	Millers Run	4 1/2 miles
	Bentlyville Municipal Dam	5 acres
	Dutch Fork Creek	3.5 miles
	Enlow Fork	4.7 miles
	Millers Run	4 1/2 miles
	Little Chartiers Creek	6 miles
	Langlockeloth Dam	15 acres
	Gamelands P #245	3 acres
	Kings Creek	3 miles
	Cokesburg Reservoir	8 acres
	Templeton Fork	2.5 miles
	Pike Run	4.8 miles
	Cannonsburg Lake	70 acres
	Dutch Fork Lake	91 acres
	Mine 60 Dam	10 acres
	Cross Creek Dam	258 acres - but currently empty
	Cross Creek	2.5 miles
	Ten Mile Creek	14 miles
	Wheeling Creek - Enslow Fork	7 miles

Appendix - Table 5 (cont.)

Fishing Areas
Monongahela River

County		Area
Westmoreland	Keystone State Park	78 acres
	Linn Runn	2 miles
	Mamouth Park	30 acres
	Acme Dam Chestnut Ridge Park	40 acres
	Twin Lakes	30+40=70 acres
	Northmoreland Park	1.5 acres
	Loyalhanna Lake	250 acres
	Lake Donegal	92 acres
	Bridge Port Dam	150 acres
	Youghegeny River (Fayette also)	2061 acres[1]
	Allegheny River	3 miles

Total Acreage = 13178[2]

Total River Miles = 62.5[3]

[1] The total acreage was estimated for each of these rivers. They are known to be good fishing areas, but the actual acreage fished was not available

[2] Excludes Cross Creek Dam (Washington County).

[3] This is the number of miles that have been certified for stocking. The actual number of river miles is much greater.

Appendix - Table 6

Mahoning River Area: Water Based Recreation - Major Recreational Areas

County	Key to Figure IV-9	Name of Area	Administrative Agency	Acres Total	Acres Land	Acres Water	Activities Boating	Activities Fishing	Activities Swimming
Mahoning	23	Hamilton Lake	OH Water Svc.	104	0	104	x	x	
Mahoning	24	New Middletonn Sports Club	Private	64	60	4		x	
Mahoning	25	Rolling Meadows Lake Park	Private	80	77	3		x	
Mahoning	26	Canfield's Sport Cons. Club	Private	102	100	2	x	x	x
Mahoning	27	Western Reserve Lake	Private	95	80	15		x	x
Mahoning	28	Eastern Ohio Cons. Club Farm	Private	78	72	6		x	
Mahoning	30	Berlin Reservoir	COE	2059	735	1324	x	x	
Mahoning	30	Berlin Reservoir Wildlife Area	DNR	570	570	0		x	
Trumbull	32	Mosquito State Park	DNR	11833	3983	7850	x	x	x
Mahoning	33	Mill Creek Park	Youngstown	2389	2213	176	x	x	
Mahoning	34	Evans Lake	OH Water	566					
Mahoning	29	Lake Milton	Youngstown	2856	1171	1685	x	x	x
TOTAL	11,735								

Source: Northeast Ohio Water Plan, 1972

Appendix - Table 7

Black River Area
Fishing Acres - Lorain County

Private	Acres
Belden Scount Res.	9
Crystal Springs Beach Club	5
Fireland Reservation Club	8
Izaak Walton League	3
LaGrange Hunting and Fish Club	7
Oak Park Lane	3
Pheasent Run Village	1
Royal Crest Golf club	8
Spring Lake Park	5
Panther Trails Campground	1
Subtotal	50
Public	
Camden Reservoir	1
Charlemont Reservation	1
Findley State Park	93
Indian Hollow Reservatin	2
Kipton Reservation	20
Carlisle Reservation	16
Municipal Dock	1
Oberlin Reservoir	13
Vermillion River Reservation	1
Waterworks Park	2
Wellington Reservoir	107
Wellington Upground Reservoir	185
Subtotal	444
TOTAL	494

Appendix - Table 8

Monongehela River--Scenario 1

Stage I

Probability of Fishing Participation

Variable	Coefficient x	Mean Value of Sample Population
Intercept	-1.07754	
Age	2.024	36.6
Agesq	1.50	1343.2
Sex	-.655	.52
Metro	-.244	-800
Inch	.006	.007
INACKE	.046	5,922
HEAD	- .058	.34
Total (Without Intercept)	-.377	

$P_{fish} = .1829$

Stage II

Probability of Doing Some Fishing for Particular Species Groups Before and After Implementation of BAT Regulations

Variable		Some Trout Fishing	Some Bass Fishing	Some Rough Fishing
Intercept		.9547	.4399	.3401
Inch	15,800	.094	-.031	-.047
Age	35.62	-.135	.0466	-.167
Ageq	$(35.62)^2$	.026	-.060	.011
Sex	.141	-.006	-.010	-.003
Metro	.76	-.013	-.036	-.044
T Bag	2.8	.08	-.043	.021
BP Bag	3.8	-.07	.020	.027
C Bag	0.2	0	.000	.000
	/.82	-.255 .349	.271/.370	.232/.317

Appendix - Table 8 (cont.)

Stage III

Days of Participation Per Season Equations by Species

Dependent Variables	Mean Values Trout	Bass	Rough	TROUTDA	BAPADA	ROUGHDA
Intercept				8.3626	12.3758	9.7833
^{1}Age	34.45	34.53	32.48	7.720	7.158	-0.043
!Pref	.34	.36	.34	.259	.700	.088
^{1}Agesq	1408.63	1410.04	1260.18	-3.23	-2.680	8.317
^{1}Sex	.13	.13	.13	.385	-.587	-.127
^{1}Metro	.69	.66	.61	-.648	-.554	.597
^{1}Inch	15,606.	15,446	14011	-1.2418	-1.540	.840
^{2}T Bag	2.51	2.8	2.8	.721	-1.984	-1.397
^{2}B Bag	6.27	3.8	3.8	-.290	.372	.350
^{2}C Bag	1.58	.2	.2	.030	-.060	-.020
^{3}RFFTRAC	.001	.001	.001	.007	-.005	-.005
^{3}RFFTRAC	.004/.006	.004/.006	.004/.006	-.034/.051	.030/.045	.088/.012
^{3}RFFRAC	.001/0	.001/0	.001/0	-001/0.0	.007/0.0--	.008/0.0

Days Before Regulation - 11.648 Trout
13.201 Bass
14.909 Rough

Days After Regulation - 11.632 Trout
13.223 Bass
14.913 Rough

---

[1] These were taken from user specific data in the Vaughan and Russell study Table 4-16.
[2] These were taken from fishers specific data Table 4-5.
[3] These were calculated using county data.

4. Boating Benefits--Participation Approach

4.1 Framework

The effect of water quality on the level of recreational boating has been well demonstrated. The number of participants within a given population as well as the number of days of boating participation per year show significant increases with improvements in the quantity and quality of available waters (Davidson, Adams and Seneca, 1966).

The nature of boating participation yields water quality improvement benefits which are dual in character. Pre-improvement participants in the region who continue to boat on the specific improved site realize increased utility from the improved quality of the experience. In addition, increased activity due to new boaters, and the increased activity of previous boaters, generate further benefits.

The effect of a water quality improvement on the utility of boating participants is demonstrated by Figure III-2.

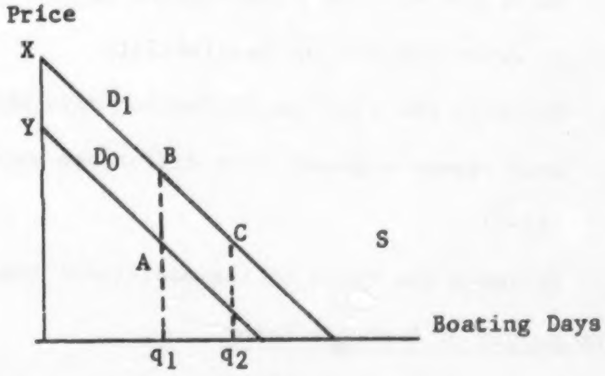

Figure III-2

Recreational Boating Benefits of BAT Regulations

The improvement in water quality created by the iron and steel BAT regulations increases the demand to participate in recreational boating, as depicted by a shift in the demand curve from D_0 to D_1. This outward shift of the demand curve increases the "consumption" of recreation boating from q_1 days to q_2 days.

The increase in consumer surplus generated by the regulation--the net economic benefit--is represented by the area YACX. This total gain is composed of an added net benefit from existing boating days, represented by the area YABX, and the net benefit of additional boating days, represented by the area ABC.

To estimate the value of the water quality induced increase in boating, the key steps in the analysis are:

1. Estimate the increase in recreational boating water resulting from implementation of BAT in each case river region.
2. Estimate the change in the probability of boating participation among the adjoining populations as a result of the improvements in water quality and availability.
3. Estimate the total participation days attributable to the relevant case stream segments (the difference between q_2 and q_1 in Figure III-2).
4. Estimate the value of the additional boating days.

4.2 The Supply of Boatable Water

The supply of boatable water has been demonstrated to be a critical determinant of the level of recreational boating.[1] Boatable water is in turn determined by the depth, width, access, and quality of the river. Table III-12 contains an inventory of recreational boating water in the case river regions.[2] The relevant measure of boating

Table III-12

Recreational Boating Water Supply in Case River Regions

River Region[a]	Recreational Boatable Water Supply	Case River Water Supply	Percent Increase
Mahoning	101 Canoe Miles	20 Canoe Miles	19.8
Black	29 Canoe Miles	6 Canoe Miles	20.7
Monongahela	8,931 Boating Acres	2,700 Boating Acres	30.2

---

[a] The Mahoning River region includes Ohio's Recreation Planning Region 11. The Black River region is Ohio's Recreation Planning Regions 10A. The Monongahela River region consists of Pennsylvania's Uniform Planning Region 10. (See 1980-1985 Ohio Statewide Comprehensive Outdoor Recreation Plan, p. 18, and Pennsylvania's Recreation Plan, 1975, p. 22.)

water for the Mahoning and Black Rivers is miles of canoe streams due to the unsuitability of these streams for power boating.[3] Total boatable water acreage is the appropriate measure for the Monongahela River which has sufficient depth and width to support large pleasure (i.e. power) boats.[4]

Ten miles of the Black River and roughly 25 miles of the Mahoning River are judged to be unsuitable for canoeing due to lack of depth, portage, or access. And, 940 acres of the Monongahela River are judged to be suitable for boating at present. It is assumed that the remaining acreage of the case rivers will be made suitable for recreational boating by application of BAT to the iron and steel dischargers. The percentage increase in boating water resulting from application of BAT to iron and steel plants along the case rivers appears, for illustrative purposes only, in the right-hand column of Table III-12.

Table III-13 shows calculation of the per capita increase in recreational boating water which will result if the case rivers are made suitable for recreational boating.

Table III-13

Increase in Per Capita Recreational Boating Water In Case River Regions

River Region	River Water Supply	Region Population	Per Capita Increase
Mahoning	473[a]	638,500	.00074
Black	191[b]	274,909	.00069
Monongahela	2,700[c]	2,219,848	.00122

---

[a] Excludes 366 acres unsuitable for boating.

[b] Excludes 127 acres unsuitable for boating

[c] Excludes 940 acres which are currently suitable for boating.

4.3 Estimating the Change in Boating Participation on the Three Case Streams

As noted previously, an increase in the supply of recreational water has been shown to significantly increase the level of participation (demand) in recreational boating. Davidson, Adams and Seneca (1966) estimated, for instance, in a study of the Delaware estuary that each increase in recreational boating water of one acre per capita resulted in a 38% increase in participation rates (i.e., the probability of any individual participating increased 38%)[5]. An index of the quality of boating facilities--rated by experts on a scale from 1 ("no facilities") to 5 ("very good facilities")--also was found to be strongly related to participation.

The Davidson et al. boating participation equation may be expressed in the following abbreviated form:

(1) $\Delta BP = .38485\ (\Delta W) + .03142\ (\Delta FPS)$

where: ΔBP is the probability of boating participation

ΔW is the acreage of recreational water available per capita.

ΔFPS is the recreational facility rating.

Davidson et al. use a rating of fishing facilities (FPS) rather than one of boating facilities because the later was not available for their sample areas . They state, however, that "since the ratings are based on the availability and development of natural water facilities, the use of the FPS variable was not entirely arbitrary." The statistical significance of the W variable accords with the authors' a priori judgment that "The inconvenience and cost of boat maintenance plus the high initial capital expense for boating necessitates the availability of sufficiently good facilities in a nearby area." The socio-economic variables which were also included in the Davidson et al. equation--income, education, occupation, race and age--were not found to be well correlated with boating participation.

Davidson et al. assume that elimination of pollution discharges into the Delaware estuary will produce a one point improvement--from 2.0 to 3.0--in the recreational rating for that body of water. A similar rating for the case rivers on the basis of improvements postulated from application of BAT at iron and steel plants along the case rivers does not exist. We therefore use a rating improvement of one for the case streams (i.e. that BAT will produce a one point improvement in the recreational rating of the case rivers). This is supported by the fishing improvements noted in the previous section of the report.

In order to calculate the BAT-induced additional boating days on the case rivers: it is also necessary to determine the number of days of boating per year per participant. Again, we adopt the Davidson et. al. estimate of 3.82 days per year. This may understate participation substantially as an average annual use rate of 9.1 per participant has been noted in the case study region.[6]

The calculation of the total additional boating days projected to result from application of BAT to iron and steel plants along the case rivers is demonstrated in Table III-14. The change in the probability of participation, ΔBP, as calculated from equation (1), is multiplied times the number of people in each region, giving the projected increase in the number of participants, this figure is then multiplied times the boating days per participant to get the total projected additional boating days.

Table III-14

BAT-Induced Additional Boating Days on Case Rivers

River	ΔBP	x	Regional Population	x	Days/ Participant	=	Additional[a] Boating Days
Mahoning	.0316		638,500		3.82		77,318
Black	.0317		274,909		3.82		33,277
Monongahela	.0319		2,219,848		3.82		270,405

---

[a] Calculation cannot be reproduced exactly because ΔBP has been rounded.

Table III-15

Recreational Boating Benefits from Application of BAT to Iron and Steel Plants Along the Case Rivers

River	$/Boating Day		No. Additional Boating Days	Total Boating Benefits (Thousands 1981 $s)
Mahoning	High	34.85	77,318	2,695
	Low	16.76	"	1,296
Black	High	34.85	33,277	1,160
	Low	16.76	"	558
Monongahela	High	34.85	270,405	9,424
	Low	16.76	"	4,532

4.4 Valuation

As the last step in the benefit calculation, it is necessary to ascribe values to the additional boating days. For this purpose the same values which are derived later, in Chapter 5 (Recreation Planning Standards) are used here. These values range from $16.76 to $34.85 per boating day. The benefit estimates, presented in Table III-15, are derived by multiplying the number of additional boating days by these dollar values. These values appear in Table III-15 as estimates of the total recreational boating benefits from application of BAT to iron and steel plants along the case rivers.

4.5 Interpretation of Results

The projected number of additional boating days reported in Table III-13 is not unreasonable in relation to observed current average boating levels as presently in Chapter 5 below. These average use densities yield 76,752 canoeing days on the Mahoning River; 14,812 canoeing days on the Black River; and 115,394 boating days on the Monongahela River.

Our method of benefit estimation attributes all of the benefits of water quality improvement to new participants. As stated above, benefits also accrue to any boaters who used the rivers prior to the clean-up in lieu of travelling to more distant sites and who continue to boat in the improved rivers. This would indicate that benefits estimated above may be understated.[7]

Benefits may be understated for other reasons. Although the Monongahela River region has a population roughly comparable to that of the Deleware estuary region studied by Davidson et. al., the Mahoning River region and the Black River region have populations considerably smaller than the Davidson et al. study region. While population does not affect benefits via the water acreage variable which is calculated on a per capita basis, it does so via the recreational rating variable. Further, the estimate of 3.82 boating days per year which reflects the boating participation rate prevailing in the Delaware estuary is less on a per capita basis than for the case river regions (see footnote 6). Since participation is strongly related to the recreational water supply, it seems likely that the boating days per year in areas with higher acreage per capita of recreation water would be greater.

FOOTNOTES

1. The Davidson, Adams and Seneca study demonstrates the importance of "supply" variables in the boating participation equations.
2. The inventory is from five year recreation plans prepared by the Ohio Department of Natural Resources and the Pennsylvania Department of Environmental Resources.
3. The lower 6.5 miles of the Black River are suitable for power boats. Therefore, the boating estimates might be understated in the text.
4. Since much fishing currently is conducted from boats there may be some double counting if all the benefits calculated in this section are attributed to boating.
5. The Adams, Davidson and Seneca coefficients are estimated using national data. Extrapolating from the national to the local river area implies that the three rivers represent "typical sites" in some sense.
6. The Pennsylvania Recreation Plan, 1980-1985 states that average participation levels for boaters are 9.1 days per year, two or three times greater than the participation level applied by Davidson et al. (and used in this analysis as well).
7. Congestion is one factor not accounted for by this technique. If congestion was taken into consideration, estimated benefits might be greater as new sites relieve crowding at existing sites.

5. Fishing and Boating--Recreation Planning Standards Approach

5.1 Recreation: Peak Day Use Densities

In this section, alternative estimates of recreation benefits are derived on the basis of "peak day" usage reported by Ohio and Pennsylvania residents in response to surveys conducted by the Ohio Department of Natural Resources and the Pennsylvania Department of Environmental Resources.[1] We also make reference to Recreation Planning Standards (RPS) that are intended to gauge "optimum" recreational use levels which, although necessarily involving conjecture, are described as the product of "an extensive literature review and the administration of a survey of recreation professionals in Ohio".[2]

Current recreation densitites (CRD) for the three case river regions are reported in Table III-16. Densities for canoeing are reported for the Black and Mahoning Rivers because power boating is not possible on these rivers. Power boating is, however, the predominant kind of boating on the Monongahela River which is unattractive to canoeists due to barge and power boat traffic. These densities reflect observed, average use levels on peak days,.

For purposes of comparison we report the Ohio Recreation Planning Standards, intended to represent optimum use densities, in Table III-17. the combined standards for boat fishing and shoreline fishing are equivalent to approximately two fishermen per acre on the Black and Mahoning Rivers and 1.2 fishermen per acre on the Monongahela River. We see that current recreation densities equal or exceed the RPS for all three rivers.

Table III-18 shows calculation of the total annual person activity days for each activity and river.

Table III-16

Current Recreation Densities (CRD) in Ohio and Pennsylvania Case River Regions

Case River Regions[a]	Activity	Supply[b]	Peak Day Usage (Person Days)[c]	CRD (Person Days/Supply Unit
Mahoning	Fishing	49,356 acres	100,297	2.0/acre
	Canoeing	180 miles	17,704	98.4/mile
Black	Fishing	23,451 acres	96,000	4.1/acre
	Canoeing	285 miles	18,031	63.3/mile
Monongahela	Fishing	124,922 acres	356,878	2.9/acre
	Boating	243,481 acres	267,763	1.1/acre

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[a] The Mahoning River Region includes Ohio Recreation Planning Regions 11, 10A, 10B and 9. The Black River Region includes Ohio Recreation Planning Regions 10A, 10B, 5B, 5A, and 4B (see Ohio SCORP, p. 8). The Monongahela River Region includes Pennsylvanis Uniform Planning Regions 7,8,9 and 10 (see Pennsylvania's Recreation Plan, p. IV-26).

[b] Mahoning River Region supply and usage is on pages 77, 79, 81 and 83, and the Black River Region supply is on pages 65, 67, 69, 79, and 81 of the Ohio SCORP. The Monongahela River Region Supply is on page IV-12 and usage is on pages V-35 and V-36 of Pennsylvania's Recreation Plan.

[c] Peak day usage is expressed as household "Activity Occasions" in the Ohio SCORP. We have multiplied this measure times 1.5 to arrive at person activity days, with the assumption that on average 1.5 household members participate in a fishing or boating outing. The boating category in Pennsylvania's Recreation Plan includes boating, canoeing and water skiing. Three quarters of peak day participation for this category has been used to estimate boating alone, as based on the fact that boating accounts for roughly three quarters of the combined household participation rate for boating and canoeing reported in the Ohio SCORP (p. 51).

Table III-17

Ohio Recreation Planning Standards: Optimum Use Density

Activity	Planning Standard x	Number of Persons x	Turnover Rate =	Optimum Use (Persons/Day/Water Unit) x	Observed Average Use Density[a]
Canoeing	4 canoe/miles	2.1/canoe	4	33.6/mile	63.3-98.4 per mile
Fishing	.20 boats/ acre water	2.5/boat	2	1.0/acre plus 20/mile	2.0-4.1 per acre
Boating	.13 boats/ acre water	2.5/boat	2	.66/acre	1.1/acre

Source: 1980-1985 Ohio Statewide Comprehensive Outdoor Recreation Plan, pp. 46-48. The shoreline fishing standards is from the 1975 Ohio SCORP.

[a] From Table III-16

Table III-18

Total Annual Person Activity Days on Case Rivers

Case River	Activity	Current Recreation Densities (Person Days/ Supply Unit)	Water Supply Units[a]	Annual Peak Days Equivalents[b]	Total Annual Person Activity Days
Mahoning	Fishing	2.0/acre	839 acres	62	104,036
	Canoeing	98.4/mile	20 miles	39	76,752
Black	Fishing	4.1/acres	319 acres	62	81,090
	Canoeing	63.3/mile	6 miles	39	14,812
Monongahela	Fishing	2.9/acre	2700 acres	62	485,460
	Boating	1.1/acre	2700 acres	39	115,830

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[a] Twenty two miles of the Mahoning River and ten miles of the Black River appear unsuitable for canoeing either due to shallowness (Black), lack of portage, or lack of access. We attribute 940 acres of currently fishable and boatable water to the Monongahela River (see Chapter 3, Vol. III).

[b] Annual peak day equivalents are calculated from Pennsylvania's Recreation Plan (p. V-18) as total annual (person) activity days, divided by the number of summer peak activity days. The annual peak day equivalents therefore reflect total actual use. We do not use the Ohio SCORP method of calculating peak days equivalents because the method does not capture activity on days other than weekends and holidays.

5.2 Valuation

It is necessary to ascribe dollar values to our estimates of potential recreation on the case rivers. The values we use, are based on the best information and empirical findings available and are described below.

a. Fishing Day Values

Two studies, by Charbonneau and Hay (1978) and Vaughan and Russell (1981), have estimated total willingness to pay for recreational fishing. The studies have produced remarkably similar results for three classes of fish, as seen in Table III-19. The Charbonneau and Hay estimates are based on a survey in which fisherman were asked their willingness to pay for a season's fishing. The Vaughan and Russell estimates are based on a survey of fee fishing sites in which proprietors were asked the average distance traveled by patrons, the average size, number and kind of fish caught, and other variables intended to control for differences in the quality of the fishing experience between sites.

The Charbonneau and Hay estimates are used in the benefit calculation below because the Vaughan and Russell study was in draft at the time of this writing. The estimates are applied to the estimated number of fishing days to produce a range of three estimates of total fishing benefits for each river. A lower bound is produced by assuming that the rivers will be populated only by rough fish--the fish class having the lowest fishing value as estimated by Charbonneau and Hay. Upper bound estimates for the Mahoning and Monongahela Rivers are produced by assuming that they will be populated only by warmwater panfish, and an upper bound estimate for the Black River is produced by assuming that coldwater game fish (such as salmon from Lake Erie) will populate this river. Mid-range estimates are produced by using an average of the values for the applicable classes of fish for each river (rough and warm water for the Mahoning and Monongahela, and all three classes for the Black) as the value of a fishing day. Calculation of fishing benefits for the three rivers is shown in Table III-20.

Table III-19

Average Willingness to Pay for a Fishing Day

(1981 $s)

Fish Class	Charbonneau and Hay	Vaughan and Russell
Rough	20.70	19.72
Warmwater Panfish	26.27	26.10
Coldwater Gamefish	29.04	29.63

Source: Charbonneau and Hay (1978) and Vaughn and Russell (1981, forthcoming).

Table III-20

Annual Fishing Benefits from Application of BAT to Iron and Steel Plants Along the Case Rivers

River		$ Value of Fishing Day	x	No. of Annual Fishing Days	=	Annual Fishing Benefits ($ Thousands)
	High	26.27				2,733
Mahoning	Mid	23.48		104,036		2,443
	Low	20.70				2,153
	High	29.04				2,355
Black	Mid	25.34		81,090		2,055
	Low	20.70				1,679
	High	26.27				12,753
Monongahela	Mid	23.48		485,460		11,399
	Low	20.70				10,049
	High	-----				17,841
TOTAL	Mid	-----		670,586		15,897
	Low	-----				13,881

Source: Calculations by the Public Interest Economics Center.

b. Boating Day Values

Estimates of willingness to pay for a boating day derived in a similar manner to those for a fishing day are not available. We, therefore, derive a range of estimates based on a study for the National Commission on Water Quality by the National Planning Association (NPA).

The value used by the NPA for a boating day, the derivation of which is not specified, is $16.76 in 1981 dollars. An alternative estimate of the value of a boating day uses the ratio of fishing and boating day values from the NPA study in conjunction with the Charbonneau and Hay fishing values. The value of a boating day is estimated in the NPA study to be 1.2 times the value of a fishing day. Multiplying 1.2 by the Charbonneau and Hay fishing day values in Table III-19 yields a range of boating day values of from $24.84 to $34.85. Accordingly, we value each day of boating between $16.76 and $34.85. These values are applied toward the projected increase in boating days in Table III-21.

Table III-21

Annual Boating Benefits from Implementation of BAT at Iron and Steel Plants Along the Case Rivers

River	Value/Day ($)	x	Annual Boating Days	=	Annual Benefits (Thousands 1981 $)
Mahoning					
High Est.	34.84		76,752		2,675
Low Est.	16.76		"		1,286
Black					
High Est.	34.85		14,812		516
Low Est.	16.76		"		248
Monongahela					
High Est.	34.85		115,830		4,037
Low Est.	16.76		"		1,941
Total					
High Est.	-----		207,394		7,228
Low Est.	-----		"		3,475

Source: Calculations by the Public Interest Economics Center.

Footnotes

1. See Ohio Department of Natural Resources, Office of Outdoor Recreation Services, *1980-1985 Ohio Statewide Comprehensive Outdoor Recreation Plan*, Columbus, 1980, p. 48; and the Governor's Office of State Planning and Development, *Pennsylvania's Recreation Plan-1975*, Harrisburg, 1976, p. V-1.

2. See Ohio SCORP, p. 49.

6. The Willingness to Pay for Clean Water: The Survey Approach

6.1 Summary

A direct survey of peoples' willingness to pay (WTP) for clean water is an alternative to indirect valuation of water-based recreation on the basis of travel cost, site fees or surrogate goods. The willingness to pay method also serves as an alternative to estimating benefits for individual benefit categories[1] (i.e., fishing, boating, swimming and nonuser benefits).

The method was used by Fredrick Gramlich (1977) to estimate from household survey data willingness to pay for water of "swimmable quality" in the Boston area.[2] The coefficients generated by the model are applied to mean values of the relevant regional population parameters to estimate willingness to pay for water of swimmable quality in the three river areas.

Gramlich's study relates willingness to pay for "swimmable quality" to a variety of household characteristics, and found several of these characteristics, including income and distance from the water to be significantly related to the household's WTP for the cleanup of the Charles River in Boston.[3]

Gramlich estimates the average WTP of local households for a swimmable Charles River to be $45.68 in 1981 dollars. The introduction of socio-economic values reflective of the case river households resulted in lower average household WTP than was obtained using the Boston data. Estimates derived for mean household WTP were from $36 to $37 for the clean up of the three case study rivers.

A range of three WTP estimates is produced in this chapter. This is done by altering the size of the relevant local populations and consequently the mean value of the distance variable used in the WTP equation. The range of estimates is reported in Table III-22. Gramlich's model and our method of extrapolation to the case rivers are described in detail in the following section.

6.2 Description of Model

To estimate household willingness to pay (WTP) for "swimmable water quality," Gramlich uses linear and double-log equations for each of three sets of variables. For statistical reasons, the linear equations are more appropriate for extrapolation to the case river regions on the basis of alternative independent variable values (p. 194, f. 19). The two linear equations employed to estimate the WTP of residents nearby the Mahoning, Black and Monongahela Rivers for swimmable water quality are:

$$(1)\quad \begin{aligned} WCB = {} & a_0 + a_1\ INCOME + a_2\ USE + a_3\ GRADSTUD + \\ & a_4\ AGE + a_5\ HSCHOOL + a_6\ COLLEGE + \\ & a_7\ DISTANCE + a_8\ WORKSITE + a_9\ OWNFUT + \\ & a_{10}\ FUTURE + a_{11}\ PAST + a_{12}\ SWIM + v_c \end{aligned}$$

$$(2)\quad \begin{aligned} WOB = {} & b_0 + b_1\ INCOME + b_4\ AGE + b_5\ HSCHOOL \\ & + b_6\ COLLEGE + v_o \end{aligned}$$

where Gramlich defines the variables as follows:

Dependent Variables

WCB = A local household's measured yearly willingness to pay for a guaranteed improvement to swimmable water quality throughout the relevant local area.

WOB = A local household's measured yearly willingness to pay for a guarantee of swimmable water quality throughout all of the nation's other rivers.

Independent Variables

INCOME = Discretionary permanent family income

GRADSTUD = A dummy variable for current graduate student status. This adjusts for the tendency of a graduate student's current income to understate his permanent income.

AGE = Respondents age (less 48 years). Younger respondents have more control over future earnings and consumption and less attachment to their current consumption.

HSCHOOL = A dummy variable for the completion of high school. Some of the benefits of improved water quality require abstraction and scientfic understanding.

COLLEGE = A dummy for the completion of college.

DISTANCE = Distance of respondent's residence from the river.

WORKSITE = The percent of the family which either worked or attended school within five city blocks of the river (but if positive never below .5) It is designed to capture the value of incidental weekday recreation. Its effect on WOB was felt to be trival and ignored.

OWNFUT = The product of an ownership dummy (own = 1) and FUTURE defined immediately below. Cleaner water may well increae one's property value by more than the cost. Its effect on WOB is ignored.

FUTURE = The probability of future residence in this area.

PAST = The percent of the respondent's past life in the Boston area. The effect on WOB is ignored.

USE = Estimated number of hours per family member spent in recreation along the Charles River last year.

SWIM = The proportion of family members over 10 able to swim 100 yards (but if positive, never less than .5).

The regression results for these equations are reported in Table III-23.[4] Equation (2) is discussed in the following Chapter on "non-user" benefits. Equation (1) contains three variables--INCOME, USE and DISTANCE--which are significant at the 90% level or higher. Only WORKSITE has a coefficient which is not of the hypothesized sign.

6.3 Benefits

To use Gramlich's model to estimate the mean willingness to pay of residents nearby the Mahoning, Black and Monongahela Rivers, it is necessary to insert values of the independent socio-economic variables which reflect these populations. Table III-24 contains the values of the independent variables used to estimate WTP for cleanup.

Table III-22

Range of Estimated WTP of Local Residents for Swimmable Water Quality in Case Rivers Based on Gramlich Model

	ESTIMATED WTP (Thousands of 1981 Dollars)		
RIVER	LOW EST.	MIDDLE EST.	HIGH EST.
Mahoning	6,558	7,580	8,826
Black	3,074	4,409	5,958
Monongahela	16,891	20,521	24,834

Source: PIE-C calculations.

Table III-23

Gramlich Regression Coefficients for Willingness to Pay Equations

DEPENDENT VARIABLES	INDEPENDENT VARIABLES													
	CONSTANT	INCOME	USE +1	GRADSTUD	AGE	HSCHOOL	COLLEGE	DISTANCE	WORKSITE	OWNFUT	FUTURE	PAST	SWIM	
(1) WCB	3.9	1.1^a	1.0^b	14.2	-.06	9.5	5.3	-2.2^b	-5.9	-6.6	13.9	-10.4	1.8	R^2=.24
	(15.2)	(.5)	(.6)	(19.8)	(.2)	(10.9)	(8.8)	(1.7)	(10.8)	(10.4)	(14.1)	(10.6)	(9.2)	
(2) WOB	.28	.68			-.04	14.21	7.97							R^2 =.02
	(11.5)	(.62)			(.29)	(14.52)	(11.3)							

Degrees of freedom are equal to 165 less the number of variables estimated.

Standard errors are in parentheses.

[a] Indicates significance at the 95% level for a one-tailed test.

[b] Indicates significance at the 90% level for a one-tailed test.

Table III-24

Variables Used to Estimate Willingness to Pay

Variable	Charles River	Mahoning, Black & Monongahela Rivers	Mahoning River	Black River	Monongahela River
INCOME (1981$s)	24,247		20,557[a]	21,373	21,129
HSCHOOL	.66		.51[b]	.53	.49
COLLEGE	.16		.06[b]	.07	.07
AGE	.20	.31[c]			
DISTANCE	2,4		2.5, 7.5[d]	2.5, 7.5	2.5,7.5
GRADSTUD	.04	0			
USE	3.80	3.80			
SWIM	.69	.69			
OWNFUT	.45	.45			
FUTURE	.75	.75			
PAST	.71	.71			
WORKSITE	.23	.23			

---

[a] Household income is calculated from per capita income from the 1977 Per Capita Money Income Estimates for States, Counties, Incorporated Places and Minor Civil Divisions, Pub. No. 882, U. S. Bureau of Census, and the average size of Pennsylvania and Ohio households from 1980 Census of Population and Housing, Pubs. PHC 80-V-40 and PHC80-V-37. THe 1980 incomes were deflated to 1973 levels for insertion in Gramlich's equations, and the WTP estimates then updated to 1981 levels.

[b] The portion of the adult population having completed highschool and college is from the County and City Data Book, U.S. Bureau of Census, 1970.

[c] Gramlich's AGE variable is age less 48 years. The average age of the U.S. population 18 years and older is from the 1970 U.S. Census of Population.

[d] Two values are used to correspond to two different regions (groups of counties) surrounding each of the three rivers.

The values for several of the independent variables Gramlich acquired in his survey (eg., PAST, FUTURE, and WORKSITE) are not available for the case river regions. We have used Gramlich's values for these variables to estimate WTP for clean up of the case rivers. The values are not obviously inappropriate, and, according to the coefficients in Table III-23 adjustments which may be appropriate are offsetting to some extent. For instance, the residents of the regions surrounding the rivers--by and large old industrial regions--may be assumed to have spent a large portion of their past lives in these regions. In fact, the value of the PAST variable would be expected to be greater for these residents than for residents of the Boston area. It also seems plausible that the probability that the residents of the three regions would remain in these areas in the future (the FUTURE and OWNFUT variables) would be lower than for Charles River residents. Since variables all have the same sign in equation 1, changes in the directions suggested would be offsetting to some extent.

Six of the variable values in Table III-24 for the Mahoning, Black and Monongahela Rivers are different from those used by Gramlich. These six values yield lower WTP estimates for cleanup of these case rivers compared to the Charles River. This is because the values that are lower for the three rivers than those used by Gramlich for the Charles--INCOME, HSCHOOL, COLLEGE and GRADSTUD--have positive coefficients in equation (1). Similarly, the value of the AGE variable for the three rivers is higher than for the Charles and the estimated coefficient is negative.

Two values of the DISTANCE variable generated by the Gramlich model are chosen to correspond to two different measures of the population receiving benefits. The two distance values are matched with regional population data to produce a range of three estimates of total WTP. The lower estimate is produced by multiplying the household WTP estimate associated with a 2.5 mile DISTANCE value by the number of households residing in municipal subdivisions any part of which lies within 5 miles of the case rivers. The middle estimate is produced by adding to the lower estimate of household WTP, the estimate of WTP associated with a 7.5 mile value multiplied by the number of households residing in municipal subdivisions any part of which lies within 15 miles of the case rivers. The higher WTP estimate is produced by multiplying the WTP associated with a 2.5 mile distance times the number of households residing within 15 miles of the case rivers.

Appendix III-A contains the populations of the municipalities which comprise each of the two regional delineations. Table III-25 contains regional populations, the household WTP associated with each region, and the total WTP associated with each region.

Application of Gramlich's model to regions larger than that covered in his survey is justified by significant differences in population density, and hence driving time, between the Charles River Basin area and the regions covered in this study. If the driving time ratio between the Charles River area and the case river regions is 3 to 1, as seems plausible, then, attribution of a WTP value from Gramlich's equation derived from a 2.5 distance value to households residing a mean distance of 7.5 miles from the case rivers is reasonable, especially in terms of defining upper bound benefit estimates. In no case is any part of the larger regions used in this analysis more than an hour's drive from the river.

The bulk of the population within these regions is, in fact, within a 10-minute drive.[5] The results are not extremely sensitive to this assumption at any rate.

Two additional considerations governed the choice of surrounding regions: the inavailability of socio-economic data below the muncipality level, and the lack of the detailed information necessary to determine which localities are not likely to benefit from pollution abatement due to the presence of alternative recreation sites or to poor transportation.

The number and quality of alternative water recreation sites was not included in Gramlich's equation. Although this omission may have reduced the explanatory power of his equations, it should not be an important source of difference in the "true" WTP of households because the availability of alternative water recreation sites to residents of the Charles River region is not obviously different from that available to case river region residents--all have relatively abundant water recreation resources.

Table III-25

Mean Household WTP and Total WTP by Region

RIVER/REGION/COUNTY	Projected No. of HH's in 1984	x	Per-HH WTP ($)	Total WTP (thousand 1981$s)
MAHONING RIVER				
Within 5 MILES				
Mahoning Co., OH	87,350			
Trumbull Co., OH	70,641			
Lawrence Co. PA	20,907			
Total Region (5 miles)	178,898		36.66	6,558 (Low Est.)
Within 5 Miles				
Lawrence Co., PA	12,138			
Mahoning Co., OH	6,683			
Portage Co., OH	5,601			
Trumbull Co., OH	10,725			
Mercer Co., PA	7,631			
Butler Co., PA	1,776			
Beaver Co., PA	10,731			
Columbiana Co., OH	6,558			
Total Region (5-15 miles)	61,843		16.53	1,022 7,580 (Middle Est.)
Total Both Regions	240,741		36.66	8,826 (High Est.)
BLACK RIVER				
Within 5 MILES				
Lorain Co., OH	82,019			
Total Region (5 miles)	94,786		37.63	3,566 (Low Est.)
Within 5-15 Miles				
Lorain Co., OH	13,646			
Cuyahoga Co., OH	59,144			
Erie Co., OH	4,145			
Total Region (5-15 miles)	76,935		17.35	1,335 4,409 (Middle Est.)
Total Both Regions	158,954		37.48	5,958 (High Est.)

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[a] This is calculated as 6,558 plus 1,022, or as ($36.66 x 178,898) + ($16.53 x 61,843).

Table III-25 (continued)

Mean Household WTP and Total WTP by Region

River/Region/County	Projected No. of HH's in 1984	Per-HH WTP ($)	Total WTP (thousands 1981$s)
MONONGAHELA RIVER			
Within 5 MILES			
Allegheny Co., PA	397,840		
Westmoreland Co., PA	26,400		
Washington, Co., PA	26,465		
Fayette Co., PA	5,201		
Total Region (5 mile)	455,906	37.05	16,891 (Low Est.)
Within 5-15 Miles			
Allegheny Co., PA	81,904		
Westmoreland Co., PA	61,131		
Washington Co., PA	28,794		
Fayette Co., PA	42,557		
Total Region (5-15 miles)	287,952	16.93	3,630 20,521 (Middle Est.)
Total Both Regions	670,292	37.05	24,834 (High Est.)

FOOTNOTES

1. Swimmable water quality was described in the survey questionnaire as "clean enough for people to swim in and fish and wildlife to live in, but not necessarily good enough to use as a public water supply without further treatment (p. 192, f. 6).

2. In addition to asking Charles River area households their WTP for a clean Charles River, they were asked about their WTP for the clean up of all of the nation's other rivers in an attempt to capture the benefits to non-local residents of clean up of the Charles River. These benefits are a component of "nonuser" benefits (local residents also enjoy nonuser benefits) which are discussed in Chapter 7.

3. Gramlich's survey covered 165 households within the Charles River Basin in the Boston metropolitan area.

4. For a discussion of regression techniques, see pp. 185-186 of Gramlich's article.

5. Of the Mahoning River region population, 83.6% lie in cities, townships or boroughs that have some segment of their land within five miles of of the Mahoning River, 87% of the population in Lorain County, within five miles of the Black River, and approximately 82% of Allegheny County within five miles of the Monongehela.

Appendix III-A

Population Residing in Municipalities Within Five Miles and Fifteen Miles of Case Rivers

Monongahela River (5 miles)

County/Municipality	Population
Westmoreland County, Pa.	
Trafford Borough	3,662
North Huntington Township	31,517
Sewickley Township	7,095
Suterville Borough	863
Monessen City	11,928
North Belle Vernon Borough	2,425
Rostraver Township	11,430
South Huntington Township	6,366
West Newton	3,387
Total	78,673
Fayette County, Pa.	
Belle Vernon Borough	1,489
Fayette City Borough	788
Jefferson Township	2,265
Newell Borough	629
Perry Township	3,119
Perryopolis Borough	2,139
Washington Township	5,069
Total	15,498

County/Municipality	Population
Washington County, Pa.	
Allenport Borough	735
Bentleyville Borough	2,525
California Borough	5,703
Carroll Township	6,590
Charleroi Borough	5,717
Coal Center Borough	255
Donora Borough	7,524
Dunlevy Borough	463
Elco Borough	417
Fallowfield Township	5,439
Finleyville Borough	402
Long Branch Borough	610
Monongahela City	5,950
New Eagle Borough	2,617
North Charleroi Borough	1,760
Nottingham Township	2,270
Peters Township	13,104
Roscoe Borough	1,123
Somerset Township	3,150
Speers Borough	1,425
Stockdale Borough	641
Twilight Borough	298
Union Township	6,692
West Brownsville Borough	1,433
West Pike Run Township	2,034
Total	78,866

Appendix III-A (Continued)

Monongahela River (5 miles) (Continued)

County/Municipality	Population	County/Municipality	Population
Allegheny County, Pa.			
Aspinwall Borough	3,284	Homestead Borough	5,092
Avalon Borough	6,240	Ingram Borough	4,346
Baldwin Borough	24,598	Jefferson Borough	8,643
Baldwin Township	2,680	Kennedy Township	7,159
Bellevue Borough	10,128	Liberty Borough	3,112
Bethel Park Borough	34,755	Lincoln Borough	1,428
Blawnox Borough	1,653	McKeesport City	31,012
Braddock Borough	5,634	McKees Rocks Borough	8,742
Braddock Hills Borough	2,556	Millvale Borough	4,754
Brentwood Borough	11,907	Monroeville Borough	30,977
Carnegie Borough	10,099	Mount Lebanon Township	34,414
Castle Shannon Borough	10,164	Mount Oliver Borough	4,576
Chalfant Borough	1,119	Munhall Borough	14,532
Churchill Borough	4,285	Neville Township	1,416
Clairton City	12,188	North Braddock Borough	8,711
Collier Township	5,063	O'Hara Township	9,233
Crafton Borough	7,623	Penn Hills Township	57,632
Dormont Borough	11,275	Pitcairn Borough	4,175
Dravosburg Borough	2,551	Pittsburgh City	423,938
Duquesne City	10,094	Pleasant Hills Borough	9,676
East McKeesport Borough	2,940	Port Vue Borough	5,316
East Pittsburgh Borough	2,493	Rankin Borough	2,892
Edgewood Borough	4,382	Reserve Township	4,306
Elizabeth Borough	1,892	Robinson Township	9,416
Elizabeth Township	16,269	Ross Township	35,102
Etna Borough	4,534	Rosslyn Farms Borough	521
Forest Hills Borough	8,198	Scott Township	20,413
Forward Township	4,335	Shaler Township	33,712
Fox Chapel Borough	5,049	Sharpsburgh Borough	4,351
Glassport Borough	6,242	South Park Township	13,535
Green Tree Borough	5,722	Stowe Township	9,202
Heidelberg Borough	1,606	Swissvale Borough	11,345
		Thornburg Borough	526
		South Versailles	425

Appendix III-A (Continued)

Monongahela River (5 miles) (Continued)

County/Municipality	Population	County/Municipality	Population
Allegheny County, Pa. (Continued)			
Turtle Creek Borough	6,959		
Upper St. Clair Township	19,023		
Versailles Borough	2,150		
Wall Borough	989		
West Elizabeth Borough	808		
West Homestead Borough	3,128		
West Mifflin Borough	26,279		
West View Borough	7,648		
Whitaker Borough	1,615		
Whitehall Borough	15,206		
White Oak Borough	9,480		
Wilkins Borough	23,669		
Wilmerding Borough	2,421		
Total	1,185,563		

Mahoning River (5 miles)

County/Municipality	Population	County/Municipality	Population
Lawrence County, Pa.		**Trumbull County, Oh.**	
Mahoning	3,686	Southington	3,723
New Castle	33,621	Champion	9,504
Hickory	2,456	Bazetta	10,107
Union Oakwood	6,544	Braceville	3,132
Bessemer	1,293	Warren City	56,629
Taylor	1,519	Warren Township	7,940
North Beaver	4,367	Howland	20,586
Shenango	7,937	Vienna	4,344
South New Castle	879	Weathersfield	34,590
Neshannon	8,662	Newton	9,797
Total	62,302	Lordstown	3,280
		Liberty	26,827
		Hubbard	16,520
		Total	206,979

Appendix III-A (Continued)

Mahoning River (5 miles) (Continued)

County/Municipality	Population	County/Municipality	Population
Mahoning County, Oh.			
Austintown	115,427	Boardman	41,833
Youngstown	37,664	Struthers	13,624
Campbell	11,619	New Middletown	2,195
Coitsville	2,105	Springfield	5,920
Canfield	10,350		
		Total	255,935

Black River (5 miles)

County/Municipality	Population	County/Municipality	Population
Lorain County, Oh.			
Avon Lake City	13,222	Lorain City	75,416
Avon City	7,241	Elyria City	57,504
North Ridgeville City	21,522	Sheffield Township	4,170
Eaton Township	7,803	Sheffield Lake City	10,484
Carlisle Township	7,690	Amherst Township	7,016
Russia Township	11,116	Elyria Township	4,609
Amherst City	10,638	Sheffield Village	1,886
		Total	240,317

Monongahela River (5-15 miles)

County/Municipality	Population	County/Municipality	Population
Washington County, Pa.			
Amwell Township	3,563	Ellsworth	1,228
Beallsville Borough	588	Houston Borough	1,568
Canonsburg Borough	10,459	Marianna Borough	907
Cecil Township	8,923	North Bethlehem	1,897
Centervlle Borough	4,207	North Franklin Township	4,648
Chartiers Township	7,715	North Strabone Township	8,490
Cakeburg Borough	796	South Strabone Township	7,389
Deemston Borough	829	Washington City	18,363
East Washington Borough	2,241	West Bethlehem Township	1,579
Elco Borough	417	Total	85,807

Appendix III-A (Continued)

Monongahela River (5-15 miles) (Continued)

County/Municipality	Population
Westmoreland County, Pa.	
Adamsburg Borough	236
Arnold City	6,853
Arona Borough	446
Delmont Borough	2,159
East Huntington Township	8,120
Export Borough	1,143
Greensburg City	17,558
Hempfield Township	43,396
Hunker Borough	359
Irwin Borough	4,995
Jeannette City	13,106
Lower Burrell City	13,200
Madison Borough	531
Manor Borough	2,235
New Kensington City	17,660
North Irwin Borough	1,016
Penn Borough	619
Penn Township	16,153
Salem Township	7,656
Scottdale Borough	5,833
Smithton Borough	559
South Greensburg Borough	2,605
Southwest Greensburg Borough	2,898
Upper Burnell Township	2,179
Washington Township	6,906
Youngstown Borough	3,749
Total	182,170

County/Municipality	Population
Fayette County, Pa.	
Brownsville Borough	4,043
Brownsville Township	936
Redstone Township	7,681
Dunbar Township	7,605
Dunbar Borough	1,369
Bullskin Township	7,088
Connellsville City	10,319
Connellsville Township	3,739
Dawson Borough	661
Dunbar Borough	1,369
Dunbar Township	7,605
Everson Borough	1,032
Franklin Township	2,756
Georges Township	7,138
German Township	5,900
Lower Tyron Township	1,089
Luzerne Township	5,549
Menallen Township	5,201
North Union Township	15,340
South Connellsville Borough	2,296
South Union Township	10,992
Uniontown City	14,510
Upper Tyrone Township	1,913
Vanderbilt Borough	689
Total	126,820

Appendix III-A (Continued)

Monongahela River (5-15 miles) (Continued)

Allegheny County, Pa.

All municipalities not included in 5 mile region except:

County/Municipality	Population
Brackenridge Borough	4,297
Fawn Township	2,899
Harrison Township	13,252
Total (excluding above)	244,074

Mahoning River (5-15 miles)

Portage County, Oh.

County/Municipality	Population
Nelson	2,424
Garrettsville	1,769
Windham	5,729
Paris	1,629
Palmyra	2,436
Freedom	2,398
Total	16,412

Mahoning County, Oh.

County/Municipality	Population
Milton	4,444
Jackson	2,141
Berlin	2,047
Ellsworth	2,310
Green	3,239
Beaver	5,401
Total	19,582

Trumbull County, Oh.

County/Municipality	Population
Mesopotamia	1,966
Bloomfield	1,078
Greene	903
Farmington	1,747
Bristol	3,151
Mecca	2,695
Johnston	2,012
Vernon	1,635
Fowler	3,066
Hartford	2,236
Brookfield	10,935
Total	31,424

Appendix III-A (Continued)

Mahoning River (5-15 miles) (Continued)

County/Municipality	Population
Columbiana County, Oh.	
Fairfield	8,996
Unity	10,220
Total	19,216

County/Municipality	Population
Mercer County, Pa.	
Wheatland	1,132
Farrel	8,645
Shenango	4,399
West Middlesex	1,064
Lackawanna	2,814
E. Lackawanna	1,709
Wilmington	1,073
Springfield	1,904
Total	22,740

County/Municipality	Population
Butler County, Pa.	
Worth	840
Portersville	320
Muddy Creek	1,832
Lancaster	2,300
Total	5,292

County/Municipality	Population
Lawrence County, Pa.	
Pulaski	4,189
New Wilmington	2,774
Wilmington	2,561
Volant	203
Washington	750
Plain Grove	754
Scott	1,821
Slippery Rock	3,234
Perry	2,057
Wayne	3,130
Elwood City	9,203
Ellport	1,290
Wampum	851
New Beaver	1,885
Little Beaver	1,060
Enon Valley	408
Total	36,170

County/Municipality	Population
Beaver County, Pa.	
Franklin	3,772
North Sewickley	6,758
Beaver Falls	12,525
West Mayfield	1,712
Homewood	188
Big Beaver	2,815
Koppel	1,146
New Galilee	596
Darlington	377
Darlington Township	2,090
Total	31,979

Appendix III-A (Continued)

Black River (5-15 miles)

County/Municipality	Population
Erie County, Oh.	
Vermillion	10,027
Florence	2,119
Total	12,146
Lorain County, Oh.	
Braunhelm	6,705
Henrietta	1,864
Camden	1,522
Pittsfield	1,436
Wellington Township	5,408
Penfield	1,253
Lagrange	4,477
Grafton	3,021
Eaton	7,803
Columbia	6,494
Total	39,983

County/Municipality	Population
Cuyahoga County, Oh.	
Olmstead	6,976
Olmstead Falls	5,868
Berea	19,567
Brook Park	26,195
North Olmstead	36,486
Fairview Park	19,311
Westlake	19,483
Bay Village	17,846
Rocky River	21,084
River Edge	477
Total	173,293

7. Nonuser Benefit Estimates

7.1 Introduction

This chapter attempts to measure the expressed aesthetic, option, and existence values that may be attributed to the BAT effluent guidelines. These are defined as nonuser benefits and stem, in part, from the knowledge that clean water exists and will be used by others. Additional benefits are derived from the knowledge that the preserved waters will be available for use by future generations and from the existence of the option to use it personally at some future time. Water quality aspects that affect aesthetics include floating debris and oil, clarity, color, and odor. In terms of ecology, anything that reduces the ability of the water to support wildlife would be considered ecologically damaging. A fuller definition of nonuser benefits may be found in Volume I.

The expressed amount by individuals for these values suggest potentially large benefits to non-users for the relevant stream segments. And even though these benefits often are misunderstood, they must be accounted for in order to better evaluate the impact of the regulation.

Nonuser benefit estimates are most frequently derived from implied demand functions, the data for which are obtained through means such as surveys, questionnaires, and voting. Assuming that people are willing to pay to avoid aesthetic and ecological damages, these techniques are intended to yield information on the prices that consumers are willing to pay for cleaner water even though they do not intend to use it. The price information thus generated is used to construct demand equations from which the welfare changes associated with cleaner water can be measured. One major shortcoming of the willingness to pay survey method is noted by Feenberg and Mills[1] who point out that "...the essence of such surveys is that the questions are contrary to fact; that is, they ask people to value a state that does not exist." Nevertheless, in the absence of market registered data, these techniques suggest the general dimensions of nonuser benefits values.

Property value data also may be used to infer estimates of nonuser benefits. Such prices have been shown to incorporate aesthetic and ecological benefits as side-benefits and are thus consumed in concert with the conventional use character of property. Therefore, a part of any increase in property values resulting from cleaner water can be apportioned to aesthetics and ecology where relevant data are available.

One limitation to the property value approach is that it records the response of property owners to an actual change in water quality. It does not reflect what property owners would be willing to pay for potential improvements in water quality, or for improved water quality at other locations. Hence, a significant fraction of value in the form of consumer surplus may be omitted.

Three separate methodologies are employed below to calculate nonuser benefits. The first methodology involves the adaptation of a subset of Gramlich's willingness to pay (WTP) estimates for the Boston area to the case study stream segments. Gramlich's estimates will reflect the value that nonusers outside of the study area are willing to pay for improved water quality in the case study rivers. In order to determine the value of clean water to nonusers within the study area, a second methodology is utilized that adopts a percentage relationship between nonuser and certain user benefits. The sum of non-resident and resident nonuser benefits yields one set of total nonuser benefit estimates. The third methodology provides alternative estimates for each of the three rivers by disaggregating nonuser benefits from cleaning up the nation's polluted waterways.

7.2 Willingness To Pay Estimates for Non-Residents--Gramlich Model

Gramlich's willingness to pay variable as defined by WOB (see Chapter 6, above) was used to capture nonuser benefits. Recall Gramlich's second WTP equation as presented in the previous chapter:

$$WOB = b_o + b_1, \text{INCOME} + b_4 \text{ AGE} + b_5 \text{ HSCHOOL} + b_6 \text{ COLLEGE} + V_o$$

The author assumes that: "the willingness to pay equation of a family living in the Charles River watershed for an improvement [in] water quality in all other American rivers also holds for any American family's willingness to pay for swimmable water quality in all the nation's rivers other than its own..."[2] Based on this assumption, Gramlich inserts in the WOB equation (2) variable values that are reflective of the U.S. population in order to estimate a typical American family's yearly WTP to make all other American rivers swimmable. This estimate amounted to $35.08 in 1981 dollars (p. 191). Aggregation over the nation resulted in a total WTP of $2.37 billion, of which $4.87 million was allocated to the Charles River in proportion to its share of total river flow in the U.S. Adjusting Gramlich's total nonuser benefit estimate to the projected 1984 U.S. population and allocating it to the Mahoning, Black, and Monogahela River segments covered in this study results, nonuser benefit estimates have been derived for non-residents for each of these streams.[3] These results are shown in Table III-26.

Table III-26

Non-Residents Nonuser Benefits

River	Millions of 1981 Dollars Non-User Estimates
Monongahela	15.19
Black	.07
Mahoning	.78
Total	16.04

7.3 Resident Nonuser Benefits

The above benefit estimates are for nonusers who reside outside the study areas. In order to determine nonuser benefits for residents of the study area, a simple percentage relationship between fishing and nonuser benefits, as established by several previous studies has been adopted.

Specifically, research conducted by Walsh, et al., (1978),[4] Meyer (1974),[5] and Horvath (1973)[6] found that nonuser benefits amounted to 53%, 54%, and between 50% and 150% of recreational fishing benefits for residents of three specific river basins. A more recent national study by Mitchell and Carson[7] has produced nonuser benefits at roughly 88% of recreational fishing values. Accordingly, 50% of the fishing benefits presented earlier (Chapters 2 and 4) have been used as estimates of the nonuser benefits for residents of the three case study stream areas. This 50% relationship has also been used by Myrick Freeman in deriving national nonuser benefit estimates.

On the basis of this 50% relationship and the fishing estimates calculated above, residents' nonuser benefits for the three case rivers have been determined and are presented in Table III-27. In Table III-28, the resident and non-resident values have been combined to yield total nonuser benefits for each river.

Table III-27

Residents Nonuser Benefits

(millions of 1981 dollars)

River	Range of Fishing Benefits	Non-User Estimates
Monongahela	5.60 - 12.75	2.80 - 6.38
Black	1.68 - 2.83	.84 - 1.42
Mahoning	.25 - 2.73	.13 - 1.37

Table III-28

Total Nonuser Benefits

(millions of 1981 dollars)

River	Non-Resident	Resident	Total Lowest	Total Highest
Monongahela	15.19	2.80 - 6.38	17.99	21.57
Black	.07	.84 - 1.42	.91	1.49
Mahoning	.78	.13 - 1.37	.91	2.15

7.4 Nonuser Benefits--Shares of Polluted Acreage Approach

As described in Volume II, there is a range of estimates of the aggregate non-user benefits from cleaning up the nation's polluted water ways. This range is from $0.7 to $12.0 billion annually. Given these estimates of the value to non-users of eliminating pollution related problems on all surface waters, the portion attributable to each of the three case study streams may be deduced. This is calculated below according to each river's contribution to the total polluted water surface acres.

It has been estimated that there are 829,000 acres of unfishable inland water.[8] The Black River (318.6 acres) therefore comprises 0.03% of that area, the Mahoning (839 acres) 0.1%, and the lower Monongahela (3640 acres) 0.44%. Applying these percentages to the aggregate benefits range above, the nonuser benefits attributable to each river have been calculated and are presented in Table III-29. Because it is inappropriate to classify the Black and Monongahela Rivers as strictly unfishable, one should consider the upper end of the range of nonuser benefits below to be excssive.[9] Best judgement estimates of upperbound nonuser benefits (as presented in the Summary) are roughly one quarter of the total below.

Table III-29

Nonuser Benefits: Shares of Polluted Acreage Approach

(millions of 1981 dollars per year)

Rivers	Lower Bound	Upper Bound
Black	$ 0.24	$ 4.08
Mahoning	0.70	12.00
Monongahela	3.08	52.69
Total	$ 4.02	$68.77

FOOTNOTES

1. Daniel Feenberg and Edwin Mills, *Measuring the Benefits of Water Pollution Abatement*, (London: Academic Press, 1980) p. 59.

2. Frederick Gramlich, "The Demand for Clean Water: The Case of the Charles River," *National Tax Journal* 30 (1977): p. 190.

3. The difference between the non-user benefits estimated on the basis of these regional populations and larger ones used to produce a "high" estimate of user benefits below is insignificant so the latter are not *reported*. The total number of nonuser households for each of the rivers is therefore: Mahoning River--77,986,525; Black River--78,105,892; and the Monongahela River--77,457,306. The projection on the number of U.S. households was based on the 1970 and 1980 Censuses. The projected number of households surrounding the three rivers is based on the *1980 Census of Population and Housing*, Pub. PHC80-V-90 and PHC-V-37. The average annual growth rates of county populations between 1970 and 1980 is extrapolated to 1984 and the number of households is calculated by dividing county populations by the average number of persons in households reported statewide for Pennsylvania and Ohio. The portion of total U.S. stream flows is calculated from the following data: Total mean stream flow in all streams--1,233,400 mgd; Mahoning River flow--353 mgd; Black river flow--32 mgd; Monongahela River flow--6,900 mgd.

4. Richard A. Walsh, *et al.*, *Option Values, Preservation Values and Recreation Benefits of Improved Water Quality: A Case Study of the South Platte River Basin, Colorado* (Washington, D.C.: United States Environmental Protection Agency, 1978)

5. Philip A. Meyer, *Recreation and Preservation Values Associated With the Salmon of the Fraser River, Information Report Series*, No. PAC/N-74-1 (Vancouver, Canada: Fisheries and Marine Services, 1974)

6. Joseph C. Horvath, "Economic Survey of Southeastern Wildlife and Wildlife Oriented Recreation," paper presented at the 39th North American Wildlife and Natural Resource Conference, Washington, D.C., Wildlife Management Institute, April 1974 (published in *Transactions*, Washington, D.C.: Wildlife Management Institute, March 1974)

7. R. Mitchell and R. Carson (forthcoming)

8. This figure of 829,000 acreas has been calculated at Resources for the Future from a water quality model designed by Gianessi and Peskin, and is presented in Vaughan and Russell (forthcoming). An alternate estimate of unfishable waters of 612,300 acres also has been derived on the basis of the Gianessi and Peskin model.

9. The appropriate acreage figures to use for the Monongahela would be based on the projected increase in upgraded fishing waters, as opposed

to waters made fishable from unfishable. Based on the Gianessi and Peskin model, as presented in Vaughan and Russell, 468,705 acreas are upgraded from rough to sport fishing as a result of moving from BPT to BAT in all industries. The Monongahela represents 0.78% of these acres. Mitchell and Carson indicate that nonuser benefits for a comparable increment of water quality improvement (boatable to fishable, rather than unusable to fishable) is $26.18 per household. This yields an aggregate benefit of roughly $2.4 billion annually. The Monongahela's share of this total is $18.7 million. The Black River's nonuser benefits, derived by comparable calculations, would be $1-3 billion per year.

APPENDIX: DIVERSIONARY USER BENEFITS

This category focuses on the usage of water for purposes other than the aformentioned benefit catagories; (health, nonuser and recreation). Benefits from cleaner water accrue to diverters of water for production or municipal use. Treatment costs to existing diverters would be reduced upon the imposition of more strigent pollution standards. Further, benefits could accure from lowering the cost of water to potential users. In the case of the latter, however, the river source must be seen as a viable economic alternative. The behavoir of potential diverters is not easy to predict and, therefore, is not included in the benefit assessments.

We have identified only two diversionary water users along the case rivers. They are both municipal water authority treatment plants located along the Monongahela River: the Western Pennsylvania Water Co. at Becks Run (RM 4.5); and the Western Pennsylvania Water Company at Elvania (RM 25.3). The plants currently operate granular activated carbon (GAC) treatment, which is periodically supplemented by powdered activated carbon systems (PAC) when pollution concentrations are severe.

The Western Pennsylvania Water Treatment Company estimated the cost of GAC treatment as: construction cost of 3.5 million (1981$s); and annual operating cost of $353,000. The present value of these two costs is $9.38 million or $18.76 million for both plants.

PAC treatment at these two plants will be unnecessary following implementation of BAT by iron and steel manufacturers along the Monongahela River. GAC treatment, however, may not be abandoned following implementation of BAT. If it is, some minimal treatment will still be necessary due to nonpoint source runoff and natural river water impurities.

The $18.76 million present value cost of GAC treatment is therefore not a hard estimate of the savings which will accrue to the two water authorities following implementation of BAT to iron and steel manufacturers, but it does provide a rough approximation of these potential savings.

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